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THE VOLCANIC ORIGIN OF EPIDEMICS.

SEQUEL TO

ARE EPIDEMICS CONTAGIOUS?

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POPULAR EDITION

THE VOLCANIC ORIGIN OF EPIDEMICS

By JOHN PARKIN, M.D., F.R.C.S.

FORMERLY H.M.'S MEDICAL INSPECTOR FOR CHOLERA IN THE WEST INDIES

LONDON

SAMPSON LOW, MARSTON, SEARLE, & RIVINGTON

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1887

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EDITORIAL NOTE ON THE AUTHOR.

Dr. Parkin died on the 18th of March, 1886, at Brighton, at the age of eighty-five, his long and strenuous life having been devoted to the study of cholera, and similar epidemics.

The present volume containing his views, with the last corrections and additions made by his hand, is published in pursuance of a direction contained in his will.

Dr. Parkin, who was a pupil of Abernethy, and was for some time under Sir Richard Dobson, M.D., Inspector of Fleets and Hospitals at Chatham, had his attention first specially directed to the subject of cholera more than fifty years ago, when visiting India and China, during a severe outbreak.

A prolonged series of observations and experiments early satisfied him that the cause of the disease was atmospheric, and that carbonic acid gas was its antidote; and when, in 1834, he had the opportunity of putting his theory to a crucial test, and on a large scale, the result was conclusive. From that time forth, any abnormal visitation of the disease, in any part of the world, was

the signal for his departure to the scene of the outbreak. In this manner, in 1834 and 1835, he visited many provinces of Spain, and especially Valencia, Barcelona, Mataró, and Cadiz. In October, 1850, cholera appeared at Kingston, Jamaica, and by December 26th he was on the spot, treating it for many months in that city, and subsequently continuing his work at Lucea, and in Green Island, Westmoreland, and Hanover. His success in this region was so notorious that when in the following year it again appeared, he was offered the post of Her Majesty's Medical Inspector in the West Indies. In 1861, he paid a second visit to India, where he remained until the disappearance of the disease.

Partly, no doubt, through indifference, owing to the comparative mildness of the cholera outbreaks in England, partly through an erroneous notion that the results of his teaching were hostile to sanitation, his theories have met with comparatively limited acceptance in England.

In Southern Europe, however, they have received abundant recognition. In the appended list will be found the titles of most of his works, and of the foreign publications in which the efficacy of his cure has been admitted. The list is, the Editor fears, very incomplete, both as regards the foregoing, and as regards Dr. Parkin's English publications, but it is given as indicating the extent of his labours, as well as the appreciation they have met with in Europe at large.

LIST OF WORKS, ESSAYS, TRANSLATIONS, &c.,

BY

DR. PARKIN.

Suggestions respecting the Cause, Nature, and Treatment of Cholera, in *The London Medical and Surgical Journal.* 1833, pp. 151-3.

Memoria sobre et Tratamiento del Cholera Epidemico. 12mo. Barcelona. 1834.

The above was translated into French by Dr. Duval, under the title: "Mémoire sur le Traitement Curatif du Cholera Epidémique," Montpellier, 1835; and into German under the title: "Abhandlung über das Hulverfahren bei der Epidemischen Cholera. Aus dem Spanischen von der Dr. Zschokke. 8vo. Aaron. 1836.

The Antidotal Treatment of the Epidemic Cholera. 8vo. London, 1836. Second Edition. 1848. Third Edition. 1866.

The above was translated into Italian under the title: "Sull' Antidoto del Cholera Epidemico. Messina. 1837.

On the Efficacy of Carbonic Acid Gas in the Diseases of Tropical Climates. 8vo. London. 1836.

This, also, was translated into Italian under the title: Sull' Efficacia del Gas Acido Carbonico delle Malattie dei Climi Tropici. 8vo. Messina. 1841.

On Gout, its Cause, Nature, and Treatment. 8vo. London. 1841. Second Edition. 1877.

The Remote Cause of Epidemic Diseases. 8vo. London. 1841.

The Cause of Blight and Pestilence in the Vegetable Creation (*Brochure*). 1846.

The Prevention and Treatment of Disease in the Potato and other Crops. 8vo. London. 1847.

Treatment of Cholera by Carbon, and Carbonic Acid Gas. *Lancet.* 1848. Vol. ii. p. 220.

Ditto, *London Medical Gazette.* 1848. Vol. xlii. p. 1081.

On the Antidotal Treatment of the Epidemic Cholera. *Lancet*. 1848. Vol. ii. p. 156.

Suggestions on the Prevention of the Epidemic Cholera, with notes on the influence of locality, in the production of that disease, and on the immunity attaching to the vicinities of mineral springs, and other places, where large quantities of carbonic acid gas are evolved. 1848. *Lancet*. Vol. ii. p. 289.

Statistical Report of the Epidemic Cholera in Jamaica. 8vo. London. 1851.

Part II. of The Remote Cause of Epidemic Diseases. With Maps. London. 1853.

L'Antidote du Cholera Asiatique. 8vo. Rome. 1858.

The Causation and Prevention of Disease. 8vo. London. 1859.

The Utilization of the Sewage of Towns. 8vo. London. 1862.

The Cause, Prevention, and Treatment of the Cattle Plague (*Brochure*). London. 1875.

Epidemiology; or the Remote Cause of Epidemic Diseases, &c., &c. Part I. London. 1873. Second Edition. 1886.

Part II. of Epidemiology; or the Cause of Epidemic Diseases in the Animal and in the Vegetable Creation, with the Cause of Hurricanes. 8vo. London. 1880. Second Edition. 1886.

Sanitary Reform: is it a Reality, or is it not? (*Brochure*). London. 1875.

The Antidotal Treatment of Disease. 8vo. Part I. London. 1878.

Part II. of The Antidotal Treatment of Disease. Phthisis: its Cause, Nature, and Treatment. London. 1883.

Climate and Phthisis. 8vo. London. 1875. Second Edition. 1882.

THE VOLCANIC ORIGIN OF EPIDEMICS.

THAT the causes, hitherto assigned for the production of epidemic diseases, are insufficient to account for either their origin or propagation, is a truth that has been acknowledged by the majority of writers, whose opinions are of any weight. Referring to the epidemic cholera, the Committee of the Academy of Medicine, in Paris, remarks: "The precise, specific, cause of the disease,—that, in virtue of which the epidemic exists, and without which it would not have arisen—remains entirely unknown, in spite of all the speculative opinions that have been put forth on the subject."[1] A writer in the *Lancet*, also, in the historical sketch that was given, in 1832, of the epidemic cholera, observed, while referring to the origin of the disease: "What this cause is, we know not, and we know, that no one else understands it. We cannot speculate upon it; we believe it, in short, to be beyond the reach of human knowledge." "Does the epidemic cholera," asks M. Bouillard, "enter into the number of those diseases of which we know the real cause? Where is the physician, who, with his hand upon his heart, dares to answer in the affirmative. It is neces-

[1] *Report on the Epidemic Cholera.*

sary to proclaim it openly, the real agent, under the mortal influence of which the cholera morbus has burst upon us, with the rapidity of lightning, has, up to the present moment, completely concealed itself from our researches." It is refreshing, after wading through all the vain speculations, that have been broached on the subject, to listen to such avowals as these. "It is something," as M. Morin Desbrosses remarks, "to discover our ignorance, and to dare to confess it with honesty. He, who has optical illusions, will certainly take a false route. The blind man, on the contrary, proceeds circumspectly, and uses precautions, which will more probably lead him to his destination."[2] Having, in the first part of this work, traced all the false routes taken by those who must have been labouring under optical illusions; let us now see whether we cannot, by using the precautions of the blind man, grope our way in the midst of the darkness by which we are surrounded; until we reach that goal, where all the clouds of doubt and scepticism will be removed, and the light of truth be alone visible.

Before the doctrine of contagion was promulgated, the majority of writers, from Hippocrates down, concluded, that the cause of all diseases—both epidemic and endemic—existed in the atmosphere. Hence the aphorism of the father of medicine, *Aer est omnium rex morborumque causa.* This conclusion is generally allowed to hold good, in the present day, with the class of diseases termed endemic, which are known to be produced by the presence in the atmosphere of a poison, to which the term malaria—

[2] *Histoire de l'Epidémie du Choléra Morbus dans le Département de Loire.*

ma'laria—has been applied by Italian writers, and that of marsh poison by English ones. Hippocrates, however, made a distinction between endemics and epidemics, for although aware that the former were caused by the extrication of a deleterious substance from the soil, he ascribed the latter to a something divine—*to theion*—or to some unknown and inexplicable cause. Sydenham, the father of English medicine, arrived at a similar conclusion. He thought, that epidemic diseases were to be ascribed to "a hidden constitution of the air." Hence the term "epidemic constitution," which has been employed from that time to the present, in order to designate that peculiar, occult state of the atmosphere, which is supposed to give origin to this class of diseases. Other writers, more bold, or else dissatisfied with this state of ignorance, have attempted to define this particular condition of the atmosphere—a circumstance not to be wondered at, when we find, that great and unusual atmospherical vicissitudes are invariably observed at epidemic periods.

Generally speaking, epidemic diseases have been preceded by unusual heat and drought; while they usually return during the summer of cold climates, and the hot months of intertropical ones. Hence, heat has been regarded, by some writers, as one of the chief, exciting causes of pestilence—a very old idea. It is to the arrows of Apollo, or the rays of the sun, that Homer ascribed the cause of the pestilence from which the Greeks suffered at the siege of Troy. "On mules and dogs the infection first began; and, then, the vengeful arrows fixed in man." Hippocrates has also remarked, that the constitution of the air, which preceded pestilential diseases, was attended, in that part of the world (Greece), by

great heat, and by southerly winds. But heat alone cannot be the cause of epidemic diseases, for they sometimes make their appearance in the middle of winter, independently of the fact, that they prevail in all situations and in all latitudes. The pestilence of A.D. 543, according to Procopius, invaded some places in the summer, and others in the winter. Evagrius makes the same remark of the plague of 590. This was also the case with the plague of the 14th century; while the pestilence of 1591 raged in Revel, in the 59th degree of north latitude, in the midst of a severe winter. Small-pox assumes as severe a form in the Arctic regions as within the Tropics; while the plague has committed as great ravages in Russia, even in the midst of winter, as in Egypt. Although confined, in the present day, to the region of the Mediterranean, the plague appears there under very different atmospherical conditions. At Constantinople, it usually breaks out in July, when the temperature is about 95° F.; but, in Egypt, it commences in November, when the thermometer is as low as 68° F. The epidemic cholera, also, on its first invasion, broke out at St. Petersburg, in the middle of winter, and with the thermometer 20° below the freezing-point. Heat, therefore, cannot be an exciting cause of epidemic diseases.

Nor can a dry state of the atmosphere have more influence in the production of these diseases, for they sometimes prevail in the very opposite condition, or that of extreme moisture. Thus, the epidemic cholera commenced in Bengal, on its first invasion in 1817, in the height of the monsoon, or the rainy season, and when the country about Jessore was covered with sheets of water from the heavy rains. The plague, also, not only

prevails in wet weather, as well as in dry, but the ravages of it would appear to be increased during such a state of the atmosphere. Larrey states, that the attacks of plague, in Egypt, were constantly augmented in wet weather. Peignet also remarks: "It is inconceivable how the number of patients increases every time that the atmosphere becomes more humid." Hippocrates and Galen have made the same remark.

Moisture, on the other hand, cannot be necessary for the production of epidemic diseases, which prevail as frequently, if not more frequently, during dry than in wet weather. For instance, at Chuprah and at Arcot the cholera commenced before the rains had set in, and when the weather, for a month previously, had been excessively dry and sultry. In fact, Mr. Davies, in his letter, attributed the origin of the disease in that spot to the extraordinary dry season and sultry weather; for he adds, "We have every reason to trust for the setting in of the rains, which can alone relieve us from the noxious miasmata." The disease, therefore, as was well observed by a writer in the *Asiatic Journal*, having shown itself at Chuprah after excessive drought, and in Bengal in the midst of continued rains, sets at defiance all theories resting on the state of moisture and dryness of the atmosphere. The same results have been observed in other countries, in hundreds of instances, since that period. Even influenza, contrary to what we should have expected, cannot be referred to atmospherical vicissitudes. It prevails alike within the tropics, in the highest inhabited regions of the north, and during all conditions of the weather. Referring to the influenza that attacked the horses in America, in 1872-3, one

writer remarks: "Epizootic influenza does not spread by virtue of any of the recognized atmospheric conditions of cold, heat, humidity, season, climate, or altitude. The disease prevailed, and was propagated in the cold of a northern winter, and in the summer heat of Central America; in the dry air of Minnesota, and in the moist air of the sea-board: at an altitude of 5000 feet above the sea—at Saltillo, Mexico—and on the low levels of New Orleans—10 feet above sea-level—and Galverston, Texas, 5 feet above sea-level."[3]

Again; a change in the electrical state of the atmosphere, especially a diminution of it, has been assigned as the immediate cause of epidemic diseases. This is more particularly the case with Noah Webster, who remarks: "It is proved by experiments, that the fibres of living animals are the most perfect conductors of electricity; while the integuments, which cover them, are non-conductors. A consequence of these principles will be that, in all the motions or operations of electricity in the atmosphere, the nerves must be the principal subjects of its influence. Hence, if the atmosphere is, at times, electrified beyond the degree which is usual and necessary, to preserve the body in a due state of excitement, the nerves must be too highly excited; and, under a continued operation of undue stimulus, become extremely irritable and subject to debility."[4] This debility is, as the writer infers, the cause of the different varieties of fever—both eruptive and ordinary—of influenza, and of the whole class of epidemics. Mr. Orton and other recent writers have adopted the same

[3] *Philadelphia Medical Times.*

[4] *History of Epidemics*, vol, i., p. 316.

views, with respect to the epidemic cholera. But the prevalence of epidemics, during every known condition of the atmosphere, when it is in a state of positive as well as of negative electricity, forbids our referring them to the influence of this agent. Besides, the living body, as the writer of the *Madras Report*, on the epidemic cholera, truly remarks, may be negatively electrified, as well as positively, without suffering more inconvenience in one case than in the other. Instances are frequent of men and animals being even struck down by lightning, and remaining stunned for a time, without experiencing any permanent injury. The animal frame, therefore, seems capable of resisting very great changes in the quantity and kind of electricity, without producing the least injury, or any morbid phenomenon. Independently of the above, again to quote the opinion of the writer of the above valuable report, all the atmospherical phenomena, and other circumstances, brought under the head of occasional causes, have, with little or no interruption, existed from the beginning of time, without producing such a disease—at least during historical periods. There are, however, certain facts, which show very clearly, that the electrical condition of the atmosphere is altered at such periods. This was remarked more particularly at St. Petersburg, during the prevalence of the cholera there in 1848. It was stated in a letter in the *Times* (July 21, 1848), "that scientific men, who have made their observations from the outbreak of the epidemic, in regard to the influence of the magnet, have discovered that during the last few days—since the disease has been on the decrease—its power has considerably increased. It has been proved that, in the course of the

week, from the 5th to the 12th July—when the disease was at its height—a magnet which lifted (previously) a weight of 40 lbs., could not lift more than from 4 to 5 lbs. weight during this period. Yesterday, its power had increased to 16 lbs." Again: the epidemic cholera has been frequently ushered in by a storm, or, if prevailing previously, its intensity and malignancy have been immediately increased. This was the fact, during the prevalence of this disease at Lucea, Jamaica, every fresh case, on the day that a storm burst over the town, having presented a malignant form; while the symptoms of those previously attacked, were more or less aggravated. In addition to this, there were several relapses. On the other hand, it has sometimes been observed, that an epidemic, which had commenced or been prevailing during serene and settled weather, has been arrested in its progress, or had its ravages sensibly diminished, by the occurrence of a thunderstorm. Electricity, therefore, cannot be the cause of epidemic diseases.

Although unable to account for the production of this class of diseases by the causes just considered, a variety of circumstances would seem to prove, that the morbific agent is present in the atmosphere. Thus, a change in the direction of the wind has sometimes made a difference in the prevalence or in the progress of the epidemic. During a visitation of the plague in Sweden, in 1710, "it was observed, that when the north wind blew, the mortality was perceptibly less; during an easterly or westerly wind it was somewhat increased; but, when the south wind came, which was the most usual, the pestilence raged like a violent conflagration."[5] It was also re-

[5] Broberg, *On the Plague in Stockholm.*

marked, that the progress of the epidemic cholera, during the first year of its appearance in India, was slower from Ganjam to Nellore than it was from the latter district to the remaining southern portion of the coast, after the wind had set in from the north-east. Again: M. Bally stated, at a meeting of the Academy of Medicine, Paris, that the wind, during the prevalence of cholera at Lille, suddenly became northerly. No fresh cases were observed after this until the wind again changed, and blew from its old quarter. Nowhere, perhaps, was the influence of the wind, in increasing the ravages of a disease, better observed than at Trinidad, during the prevalence of the epidemic cholera in that island, in 1854.

Port of Spain, the capital of Trinidad, is a very well-built town, the streets running in a straight line, and intersecting each other at right angles. The town, in fact, forms nearly a square—one side facing the north, and the opposite one the south, or nearly so. As Trinidad lies in the track of the N.E. trade-wind—changed, as it blows over the town of Port of Spain, by the configuration of the land, or the neighbouring mountains, into a nearly easterly wind—it follows that the houses in those streets, running parallel to the direction of the wind, will be all equally exposed to its influence. In those streets, on the contrary, that are perpendicular to the direction of the wind, the houses on the windward side would necessarily be more exposed to its influence than those on the leeward side. This will be rendered more apparent by a reference to the sketch in the Appendix, made from memory; a plan of the town, that I brought away with me, having been destroyed in the fire at the Pantechnicon, a few years since.

Dr. Clarke, staff surgeon, then stationed in the island, wishing to ascertain the exact mortality that had occurred in the town, and finding it impossible to obtain correct data in any other way, took upon himself the task of going from house to house, in order to ascertain the number of deaths in each. In so doing, some curious facts, which are exhibited in the following Table, copied from Dr. Clarke's Report, became manifest.

TABLE A.—*Rate of Mortality in the undermentioned Streets, in Port of Spain.*

Streets running North and South.	Deaths *per cent.* of the population.	
	East side.	West side.
1. Duncan Street	11·8	10·0
2. Nelson ,, ...	11·2	9·7
3. George ,, ...	12·6	7·9
4. Charlotte ,, ...	11·4	7·5
5. Henry ,, ...	11·1	8·9
6. Chacon ,, ...	10·2	7·6
7. Edward ,, ...	10·7	5·0
8. Vincent ,, ...	8·8	6·5
Average	10·54	7·42
Difference	3·32	

NOTE.—The east side, in these streets, is the windward side, the west, the leeward side. Duncan Street, again, is the most windward of the above streets, Vincent Street, the most leeward.

By a reference to the preceding Table, it will be seen that the proportion of deaths, to population, in the houses on the windward side of those streets, that are perpen-

dicular to the wind, was three and four per cent. higher than in the houses on the leeward side of the same streets. In some streets, in which the houses, on the windward side, were more exposed than in others, the rate was still higher.

Not only was there a difference, in the rate of mortality, in the houses on the two sides of these streets, but there was also a difference on the windward and leeward side of the town. In the former, the rate of mortality was 14·10 per cent. of the population; and in the latter, 8·1—a difference of 6 per cent. So, again, there was nearly the same variation in the windward and the leeward streets. For instance, in Duncan Street, the deaths amounted to 10·54 per cent.: in the most leeward—a street beyond Vincent Street—to only 6·2 per cent. On the other hand, there was no perceptible difference in the number of deaths on the two sides of those streets that run parallel to the wind. The only variation was at the two extremities of the streets. Thus, in Upper Princes Street, which is the windward end, the rate of mortality was 7·8 per cent.; but in Lower Princes Street, the leeward end of the same street, the rate was only 2·1. In Queen Street, which is rather more exposed to the trade-wind than Princes Street, the rate was 11 per cent. at the east, or windward end; 7·8 in the middle, and 6·0 at the western extremity. Another result is worth recording. The mortality was greater in the wide open streets than in narrow ones. In Frederick Street, the narrowest and most confined street in the town, the deaths only amounted to 2·1 per cent. of the population; the average of the other or open streets being 11·2 per cent. On the other hand, those houses in the suburbs that stood alone, and

which, therefore, were particularly exposed to the influence of the wind, suffered more than any others.

As the influence of the wind, in this instance, is self-evident, what, we may ask, was the occult cause of these different effects? Dr. Clarke and others thought the phenomenon could be explained on the supposition, that the emanations in the back yards of the houses, on the windward side of the streets, that run perpendicular to the trade-wind, were driven into these houses; while they were unable to enter, or were driven away from, the houses on the opposite side. These conclusions might be satisfactory enough, provided only it were shown that such emanations are sufficient to produce the effects under consideration; but that cannot be the case, if my previous deductions be of any value. Such an explanation, again, would be sufficient to account for the result observed in the other streets—those that run parallel to the wind. As in these instances the wind must have blown over the backs as well as the fronts of the houses, there would necessarily have been an accumulation of the emanations from the yards at the leeward end of these streets: where also the mortality, according to the above hypothesis, ought to have been the greatest. The contrary, however, is the fact: the mortality, as we have seen, being actually 5·1 per cent. less at the leeward than at the windward extremity of these streets. The emanations from the yards could not, therefore, have been the cause of the variations observed in the mortality of these different streets. Besides, we have observed the same phenomenon in other situations where this cause was not in operation. In London, during the outbreak of cholera, in St. James' parish, in 1854, it was remarked,

that the *east side* of the streets running north and south —the dwelling-houses being about equal on the two sides —suffered most; in streets running east and west, the *south side* was, generally, most affected. We may therefore conclude, that the direction of the wind was S.E.

Another circumstance, confirmative of the conclusion, that the agent productive of epidemic diseases is present in the atmosphere, is the following. It was a general rule, that the residents of the houses, in the villages in the interior of Trinidad, situated on the high road, suffered severely from attacks of cholera; while those living in huts, *in the bush*, as generally escaped, or were only slightly visited. The same phenomenon has been remarked in India. The chief commissioner of the Chulleesghur division of the central provinces stated, in his Report, that the villages in the open plain suffered more than those in the forest: although the inhabitants of the latter are poorer and fare worse than those in the villages and towns.[6] So, also, in Jamaica, during the severe visitation of cholera, in that island, in 1850, the highest rate of mortality was in the small villages and settlements in the interior; the lowest, in the large towns—the rate varying from 15 per cent. in the latter, to 70, 80, nay 90 per cent. in the former. Nearly all these villages are situated in hilly districts, and on elevated plains; while they are much cleaner than the houses in the towns, and better ventilated—being built mostly of bamboos, through the interstices of which the air rushes as it would through a sieve. Hence they are more exposed

[6] Dr. Bryden's *Report*, p. 234.

to the influence of the external air than the houses in the towns.

It is also worthy of remark, that females suffered more than males, in the West Indies, from the ravages of cholera.[7] In the East, however, the contrary is the case, females there being much less liable to attacks of cholera than males. The difference is easily explained. In the East, females are more confined to the house than males; while, in the West, they work in the fields, and carry the produce to market. In addition to this, during the prevalence of the epidemic, they actually did nearly all the outdoor work; while their lords and masters—the lazy, good-for-nothing negroes—lay skulking at home, having refused to do any work. It also appears, from the statistics collected by Dr. Guy, that domestic servants—the class that remains the most indoors—suffered less from the ravages of cholera in London, in 1849, than other classes. On the other hand, those that live principally in the open air—cabmen, watermen, &c.—suffered most. The inmates of the different prisons, asylums and workhouses, were only slightly visited at this period: while the patients in the hospitals, both in London and Paris, entirely escaped. This is the more worthy of note, as cholera patients in Paris were actually taken into the wards that contained other patients—thus proving, most conclusively, that this disease is not contagious, and that it is not, and cannot be, propagated from individual to individual, under any circumstances whatever. These facts are not new. Sir Gilbert Blane has stated, that the persons in the jail, hospital, and poor-houses of Phila-

[7] In the districts under my immediate superintendence, 42 per cent. of those attacked were males, and 58 females.

delphia, remained exempt from the pestilential epidemic (of yellow fever) in its utmost rage; and the same result was observed with the prisoners of war in Jamaica. In Barcelona, also, during the prevalence of yellow fever there, at the commencement of the present century, when more than 20,000 perished in the course of four months,—a third of the population—no class was spared, excepting those in the prisons, the poor-houses, and some charitable institutions!

That the immunity, in these instances, is to be referred to the exclusion of the external air, may be inferred, not only from what has gone before, but, also, from the following circumstance, narrated by Captain Claridge, author of a work on Hydropathy. "In the former visitation of the disease (cholera) in Avignon, to give air to one of the non-infected wards in the hospital, the medical man ordered the windows to be opened: immediately, on the order being complied with, it is an attested fact, a number of patients, in that ward, were seized with cholera. They were all removed to the infected department: the windows of the non-affected wards were all closed, by which means the cholera was kept out." It was also remarked, in one of the severe visitations of yellow fever, in the West Indies, that those who exposed themselves to the *outside air*, or, even, to *a current of air* within the house, were suddenly attacked with the disease.[8]

[8] With these facts before us, what are we say to say to the following recommendations, among others, issued on the approach of cholera, in 1865, by the then medical officer of the Privy Council: "Ample ventilation should be enforced. It should be seen that window-frames are made to open, and that windows are sufficiently opened. Especi-

Similar results have been observed during the prevalence of epizootic diseases. Mr. Youatt, speaking of the influenza which attacked horses in 1833, remarks: "Two or three shut up in a comparatively *close stable* would escape. So, also, of 30 distributed through 10 or 15 little (and therefore close) stables, not one would be affected; but in a stable containing 10 or 12, although proportionably larger and *more ventilated*, the disease would assuredly appear; and if it does enter one of the largest stables, almost every horse will be affected."[9] In a paper written by Mr. T. Greaves, M.R.V.C., we find the following remarks. After stating, that the contagious nature of the disease—pleuro-pneumonia—is not yet fairly established, the writer adds: "We see

ally where any kind of infective fever has begun, it is essential, both for patients and for persons who are about them, that the sick-room and the sick-house be *constantly traversed* by streams of fresh air." All we can say is, that doctors differ on this point, as well as on many others. Windows, I should say, were made to be shut, otherwise we might as well be without them, as in the case with most of the barracks in Spain. It unfortunately happened, however, during the prevalence of cholera there in 1834, that the infantry soldiers, although possessing what the above writer considers so great an advantage, suffered more from attacks of the disease than any other class. But the cavalry soldiers, who, in that primitive country are in the habit of sleeping in the stable with their horses, and who are thus obliged to inhale what some persons call the impure, contaminated, expired air of their equine companions, were only slightly visited. Not only should the windows of private houses, but those of hospitals, also, be kept shut during the prevalence of epidemic diseases: and care ought to be taken, that the *nurses do not open them* after the doctor's visit.—Vide *Notes on Nursing*. By Miss Nightingale, who recommends this rebellious act!!

[9] *The Veterinarian*, 1833, p. 117.

situated upon yonder high hill a dairy, which no expense has been spared to render everything that is likely to contribute to and ensure health. . . . We see, that the sweet, fresh breath of Heaven plays about it, and sweeps freely through the place; the ventilating shaft with the ingress upon the ground surface, and the temperature always scrupulously attended to. In this place, there are no drains, no 'grids,' nor manure-heaps, permitted to accumulate; but, in every department, cleanliness, regularity and care, are diligently and rigorously persisted in; and yet, what are the results? The morbific influence, the fell destroyer, has taken up its abode here, with only limited periods of absence; and would appear to be perfectly irrepressible by any, and every known, human agency. We see (it may be) at the very next farm, where no pretensions whatever to care or cleanliness are observed; where the hovel is so low, that you cannot stand upright in it; and the walls, and the top of the building, strangers to a brush of any kind, perhaps for thirty years; where there is *no ingress nor egress* for a breath of air, and where the manure-heap is within one yard of the door, and only removed at rare intervals of time; where the green, fetid, putrid, decomposing, animal and vegetable matter is reeking, and disgusting to the senses; yet, strange as it may appear, the disease has never visited this loathsome place. . . . How can this phenomenon be accounted for?" The writer concludes, that the disease is the effect of an aerial poison, but how produced "science is not yet able to make known to us."[1] This, no doubt, is the right conclusion, for the only way in which we can account

[1] *The Veterinarian*, vol. xxxix., p. 460, 1864.

for the effects under consideration is, by concluding, that a deleterious substance is present in the atmosphere; and that it exists to a greater extent in the external air than in that of the interior of buildings, houses, stables, &c. That the poison productive of epidemic diseases is present in the atmosphere, we may conclude, not only from what has gone before, but also from the following interesting observation or experiment. It was ascertained by Dr. Prout, during the prevalence of the cholera in London, in 1832, that the ordinary lateritious sediments disappeared from the urine, their place being supplied by oxalic acid. Dr. Prout further ascertained, that this state of the secretions was connected with a positive increase in the weight of the atmosphere, similar to what might be produced by the diffusionof a heavy, gaseous substance in the lower atmospheric strata.[2] Observing these facts, certain writers, more especially those resident in intertropical climates, have referred the production of epidemic diseases to the poison termed malaria. This agent, which, as previously mentioned, is productive of the class of diseases termed endemic, is usually considered to be a product of animal and vegetable decomposition—substances that exist constantly in the soil of those localities from which malaria is extricated in the greatest abundance. Without waiting to ascertain the truth of this conclusion—this part of the subject having been fully discussed on a previous occasion[3]—it is sufficient now to remark, that malaria cannot be productive of epidemic diseases, if we conclude, as is generally the case, that this agent is only extricated

[2] *Researches into the Weight of the Atmosphere.*

[3] Vide *Causation and Prevention of Disease.*

from the alluvial districts of intertropical climates, and the marshes of extratropical ones. Although prevailing to the greatest extent in alluvial districts, epidemics are to be met with in all situations—on elevated as well as in low localities, on secondary, and sometimes on primary formations. Nor can the agent be generated in one situation, and then be transported by winds or currents of air to other localities; for epidemic diseases have been known to progress in the face of a strong monsoon—a wind that blows regularly, for some months, from the same point of the compass. For instance, "the epidemic cholera travelled from north to south of the Indian peninsula with remarkable regularity, appearing in the line of 20° of northern latitude, in the beginning of 1818, and reaching 8° north latitude on the 1st January, 1819, being about a degree a month. During this progress, far from being assisted by winds, the disease must have frequently travelled in direct opposition to the currents, and seems never to have been retarded or advanced by their direction."[4] This circumstance was better observed, and more particularly remarked, in India, on account of the prevalence of particular winds, in this part of the globe, at particular seasons of the year, and their subsidence at fixed periods. Besides, epidemic diseases have not only attacked bodies of men on land; they have also infected ships at sea, when they were hundreds of leagues from the shore, and where, of course, the operation of an agent from such a source could not possibly be experienced—malaria becoming innocuous when largely diluted in the atmosphere. Thus persons, residing only three or four hundred yards above

[4] *Bengal Report on the Epidemic Cholera.*

the level of the marsh or jungle, escape the diseases, which are frequently productive of great mortality among those who inhabit spots nearer the source, whence the poison is given out. If these deductions be correct, it follows that we must look to some other source, for the generation of the agent productive of epidemic diseases, than that usually considered to give origin to malaria. Nor can we infer that the poison present in the atmosphere, is derived from the bodies or the breath of the sick, or other infected source. The irruption is, in many instances, too sudden to allow of such a conclusion for a single moment. On board the "Britannia," in the Black Sea, in 1854, men were attacked with cholera so suddenly, that they fell down in a state of collapse, in all parts of the ship, and even on the yards, *while reefing sails.* I witnessed a similar attack on board the late East India Company's ship "Canning," during her voyage from England to China, and while proceeding up the China Sea. In this case, infection was out of the question, as, in addition to the suddenness of the attack, we had been at sea three months, while the event occurred previously to the advent of the epidemic cholera in England. At Punderpoor, also, men were seen tumbling over each other in the public streets, as if struck by lightning; while the vi itation ceased at the end of three days—a sure proof that the disease was neither caused nor propagated by contagion.

But if we infer, that the agent productive of epidemic diseases is present in the atmosphere of particular places; and if it be also concluded, that it is not produced by any alteration in the chemical affinities and properties of the air itself; nor generated on the

surface of the earth, or, in the bodies of men, whence, we may ask, can this invisible substance be derived? If unable to account for the production of the poison above the surface, our only resource is, to glance into the interior of the globe, with the view of ascertaining whether there be any process going on there capable of giving origin to a poisonous matter. Now there is a process in constant operation in the bowels of the earth, and which gives rise, at particular periods, to certain effects cognizable to our senses: to this process the term *volcanic action* has been applied. But then it so happens, that this process is a silent and invisible one; for we are unable to penetrate into the interior of the globe, and to view the operations of nature in this her hidden laboratory. It is impossible, therefore, to ascertain its existence, except by the occurrence on the surface of some of those phenomena, known to be produced by volcanic action. The principal and the most striking of the effects, directly produced by the agency of this cause, are, as is well and commonly known, the volcano and the earthquake. "Now if we contemplate a volcano, whilst in a state of vigorous action, the phenomena presented to us are at once so peculiar, and so impressive, that it would seem unnecessary to be at the trouble of defining that, which the commonest observer could hardly fail to recognize again, in whatever part of the globe it might fall under his observation. The evolution of smoke and ignited matter from an orifice in the earth, generally situated on the summit or flanks of a conical mountain, the ejection of fragments of scoriæ, bearing a near resemblance in their condition and aspect to the ashes of an iron foundry, the sudden and copious

extrication of elastic fluid, with their natural concomitants, noise, and concussion of the rocks, through which they force their way, are circumstances which strikingly impress upon the imagination the paroxysms of volcanic action; and appear to distinguish this from all the other operations of nature."[5] But as the shock of the earthquake, and the eruption of the volcano, are the principal signs we have of this action being in existence, the only direct evidence, it may be considered, that could be adduced in support of the above hypothesis, would be the occurrence of these phenomena simultaneously with the outbreak of epidemic diseases. Such proof, however, is generally wanting; for though, as will hereafter appear, epidemics are sometimes accompanied by earthquakes, these diseases frequently prevail without being preceded or accompanied by this phenomenon—while the influence of volcanos must be too limited to allow us to draw any deductions from this source, in respect to general plagues or epidemics. "If, however," as the author before quoted truly remarks, "we limit our view of volcanic action to the phenomena attendant on the eruptions of a volcano, and the shock of the earthquake, we exclude from our definition a series of effects evidently allied to the former, and, perhaps equally illustrative of its real nature. How different, for example, are the eruptions of Vesuvius and Ætna, or any other mountain which emits a stream of lava, or melted matter, from the emanations of gas and vapour, which arise in situations where no vent exists; or, from the increased temperature of certain springs in the neighbourhood of active and extinct volcanos; or, the evolution of carbonic

[5] *Ency. Metrop.*, Art. Geology.

acid, and other gases, from the water of these as well as all other thermal springs. Yet the connection of all these phenomena, with the action which gives rise to the eruption of the volcano and the discharge of melted matter from the crater, is as well established now, as is the relation of subterranean concussions or earthquakes with the volcanic process." But, although these various phenomena may, when present, afford conclusive proof of the existence of volcanic action, we are unable to derive any evidence from this source in support of our hypothesis—for these effects are seldom witnessed, except at periods subsequent to the appearance of the volcano and the earthquake, and in spots, where these phenomena have been observed; or, where evidence exists of their former occurrence. As, therefore, these particular effects are only met with in certain localities—being scattered, like the volcano itself, irregularly over the earth's surface, while they occupy but a small portion of the habitable globe—and as epidemics extend over every part, and in situations where these phenomena are not observed, it follows that we can derive no evidence in proof of our hypothesis from the existence of the latter, any more than from the former signs of volcanic action. True, there are certain other and general phenomena, which usually accompany the march of pestilential diseases, and which, as will be inferred hereafter, are effects of the same cause; but as these phenomena are not now considered to be signs of the existence of volcanic action, it would be wrong to draw any conclusion from this source, until other and more positive proofs are obtained in support of this connection. We must therefore adopt another and a different

method, in order to prove the proposition with which we started.

The first thing, as Sir John Herschel informs us, that a philosophical mind considers, when any new phenomenon presents itself, is its explanation or reference to an immediate producing cause. If that cannot be ascertained, the next is, to generalize the phenomenon, and to include it, with others analogous to it, in the expression of some law, in the hope that its consideration, in a more advanced state of knowledge, may lead to the discovery of an adequate proximate cause.[6] The same advice has been given by Laplace,[7] who says: "*La méthode la plus sûre, qui puisse nous guider, dans la recherche de la vérité, consiste à s'élever, par induction, des phénomènes aux lois, et des lois aux forces.*"[8] This is, in fact, the inductive method of philosophizing invented by Lord Bacon, and applied with so much success to every branch of science by a number of philosophers, who have followed in the path marked out by this prophet of the art, or father of experimental philosophy, as he has been justly termed. Before his time, philosophers were in the habit of pursuing a course, that was subsequently adopted by Descartes, viz., to guess at the cause, and then endeavour to account for the effects by a reference to this power, or agent, of their own creation. This is very different to the method of Bacon, who has laid down the following axiom: "MAN, THE SERVANT AND INTERPRETER OF NATURE, UNDERSTANDS AND REDUCES TO PRACTICE JUST SO MUCH AS HE HAS ACTUALLY EXPERIENCED OF

[6] *On the Study of Natural Philosophy.*

[7] *Essai Philosophique sur les Probabilités.*

[8] *Forces* or *causes*—primary, or remote, cause as it is now usually termed.

NATURE'S LAWS; MORE HE CAN NEITHER KNOW NOR ACHIEVE."[9] Instead, therefore, of proceeding from causes to effects, he pursued a directly contrary order; and proceeded upwards from effects to causes; or, as he termed it, raising axioms from particular instances.

Now, if we generalize the phenomena attendant on the march of epidemics, we shall find, that they are so regular and uniform, as to deserve to be set down as laws of this class of diseases. More than this, if we compare these laws with those attendant on volcanic action, it will be found, that they are the same or similar, as will be apparent by the recital of a few of the principal phenomena observed during the operation of this process on the crust of the globe.

LAW I. THE FIRST AND MOST SINGULAR LAW, WHICH MAY BE NOTICED, IS THAT WHICH CAUSES THE EFFECTS OF VOLCANIC ACTION TO BE FELT OR WITNESSED ALONG PARTICULAR LINES OF THE EARTH'S SURFACE.

To be convinced of this, we have only to cast our eyes over any one of the principal volcanic regions, when we shall remark, that a series of vents extends along, at a greater or less distance, either in a straight or curvilinear direction; and this too over considerable portions of the earth's surface.[1] As an example of the first, we may refer to the Andes, where, "from Chili to the north of Mexico, there is a line of volcanos, *so uninterrupted,* that it is rare to find an intervening degree of latitude, in which there is not an active vent; and it seems probable, that they will hereafter be found to extend from Cape Horn to California, or even, perhaps to New Madrid, in the United

[9] *Novum Organum Scientiarum.*

[1] See Map 1 in the Appendix.

States—a *distance as great as the pole from the equator.*[2] Although extending to this distance in one continuous and uninterrupted line, the volcanic action is confined, as well as the effects resulting from it, to very narrow boundaries on either side. "In regard to the western limits of this region," observes the same writer, they lie deep beneath the waves of the Pacific, and must continue unknown to us. On the east, they do not appear to be prolonged to a great distance, for there seems to be no indication of volcanic disturbance in Guinea, Brazil, and Buenos Ayres." A remarkable example of the other variation or curvilinear direction is to be found in the Pacific Ocean. "From the Philippine Islands, a range of volcanic vents proceeds to nearly 10° latitude S., ranges westward along this parallel for about 25° of longitude, and then turns up north-west diagonally through about 25° of latitude. This line, which, when represented on maps, resembles an enormous fish-hook, passes from the Philippines, by the north-east point of Celebes, Gelolo, the Volcanic Isles between New Guinea and Timor, Floris, Sumbawa, Java, and Sumatra to Barren Island." Another curvilinear region, although not so well marked and clearly defined, exists in the Atlantic Ocean; the centre of this region being the West India Islands. For reasons that will subsequently appear, the eastern apex of the line, as I infer, extends as far as the southern shores of Spain. Stretching thence, along the western coast of Africa, it passes through the West India Islands, and then turns up along the eastern coast of America, as far as the 40° of north latitude, if not farther.

The principal volcanic region in the old world extends,

[2] *Lyell's Principles of Geology*, vol. i., p. 586.

from east to west, for the distance of about 1000 miles from the Caspian Sea to the Azores. From south to north, it reaches from about the 35th to the 45th degree of latitude. Its western limits, says Lyell, are the ocean, but it is impossible to ascertain how far it may be prolonged in that direction; we only know, from the phenomena that have been observed at different periods, that the line extends across the continent of America. Nor can we assign with precision its extreme eastern boundaries, since the country beyond the Caspian, and Sea of Arat, is scarcely known. An attentive consideration of the phenomena which have been observed in this part of the world, from time to time, leads distinctly to the conclusion, that the volcanic action extends along the centre of this region in a line from east to west; for while the effects of earthquakes, which have occurred at a given point, have been felt hundreds of miles from the centre of concussion, in *a lineur or western direction*, scarcely any effect has been observed in places situated but a comparatively short distance to the north or south of this particular line. This phenomenon was particularly noted in the earthquake at Lisbon; for the concussion was severely felt by ships at sea, hundreds of miles to the westward of the spot where it first commenced; while places but slightly removed from this line, to the north and south, experienced no shock, only slight agitation in the waters of the sea, rivers, ponds, &c. It would also be an easy task to show, if space were afforded for the purpose, that the concussions which have been felt in this region, and even at the farthest extremities of the volcanic line, have an intimate connection with the volcanos of Ætna and Vesuvius; inasmuch as, previously to an erup-

tion of either volcano, earthquakes have generally been experienced along some portion of this particular line, while these have invariably ceased, as soon as the melted matter has found its way to the surface. Other signs of internal action along these particular lines, and the fact, that two vents are seldom in a state of activity at the same time; while the discharge of matter from one outlet invariably lessens, or arrests, that from another, sufficiently attest their continuity beneath the surface. Thus, the volcanos in different parts of Iceland, as well as those in the Phlygrœan Fields, are observed, as Lyell states, to be in activity by turns,—one *vent often serving for a time as a safety-valve to the rest.*

In other instances, however, or in other districts, where no volcanic vent exists, and where concussions are alone observed, the same law is found to prevail. Thus, a shock having been experienced at a given spot, it is speedily propagated to another and a distant point, *and always along some particular and well defined line,* being frequently felt hundreds of miles from the part where it first manifests its effects; while places removed only a short distance from this line, on either side, are scarcely, if at all, affected. In the earthquake at Chili, the shock was felt *simultaneously* throughout a space of *one thousand two hundred miles* from north to south; while places situated a few miles only on either side of this particular line, were not at all affected. Again; on the 17th February, 1827, a violent earthquake was felt at Santa Fé de Bagota, in Columbia; and, *on the same day,* at a town in Siberia. It is worthy of remark, adds M. le Baron Humboldt, to whom we are indebted for this account, that the direction of the shock in Columbia was from south-east to north-

west, and that this direction points towards Siberia. Not less interesting is the circumstance, that the line from Columbia towards Siberia strikes the most remarkable volcanic region in Mexico, and is parallel to the principal range of American mountains. This may be received as a proof, says the above writer, *that the operation of earthquakes is propagated in a linear direction:* while, we may add, it is no less a proof, that their effects are felt, at the same moment, over large portions of the terrestrial sphere.

In the diseases under consideration, one of their most characteristic features is their progression along, and prevalence over, particular lines of the earth's surface. Although, like a range of volcanic vents, they frequently extend over the whole or a considerable part of one of the great circles of the terrestrial sphere, yet their effects are felt but at a comparatively short distance on either side of this particular line. So defined is the boundary, which marks their course, that it has not been an unfrequent occurrence to observe one side of a river affected, while the other has remained untouched; nay, even the same morbific line has intersected a town, attacking a suburb to the exclusion of the city, or *vice versâ;* and one side of the street in preference to the other.

In the black death of the 14th century, the most destructive plague of which we have any record, this law was particularly striking and well marked. This disease, as appears by the unanimous testimony of all historians, first commenced in China, or, according to Dr. Mead, in the kingdom of *Cathay,* to the northward of China; whence it spread, in a westerly direction across the continent of Asia to Constantinople. We are not acquainted with its

exact route in this part of the world: but we are told that India was nearly depopulated, while Tartary, the Tartar kingdom of Kaptshack and the contiguous countries were covered with the dead. It is also certain, from the records yet preserved, that the plague, which broke out in Constantinople in the year 1347, was the same as that which previously prevailed in the countries to the east of this city; for the historians of that period state, that the disease had been brought from the northern coast of the Black Sea; or, according to the general Byzantine designation, "from the country of the hyperborean Scythians," after having depopulated the intermediate countries. When, however, it had reached Constantinople, the great centre at that period of commercial intercourse, the disease, instead of spreading, like radii from a centre, in all directions, took one particular and well defined course by the islands and shores of the Mediterranean, until it reached the south of France. At this point, the epidemic, changing its direction from a westerly to a northerly one, passed through France and England, and thence to the northern kingdoms of Europe,—Sweden, Norway, and Russia, being visited in succession. "Instead of advancing in a north-westerly direction from Tauris and from the Caspian Sea, it had thus made the great circuit of the Black Sea by way of Constantinople, southern and central Europe, England, and the northern kingdoms, before it reached the Russian territories."[3]

[3] Hecker: *The Black Death of the Fourteenth Century.*

Referring to the Siberian plague, then prevailing in Russia, Mr. Simon remarks: "Terrible inflictions have, before now, come to us by that line of transit; and cholera is not the only pestilence, which has thus come. Apparently, it was through Russia, and,

In the epidemic cholera, also—a disease which, like the former, had its origin in Asia, and which traversed the peninsula of India, and the heart of Persia, by one particular and principal route, to the borders of the Caspian Sea—the same law has been observed.[4] Instead of following in the track of the black death, and extending along the shores of the Mediterranean, it proceeded in a northerly direction into the heart of the Russian dominions. From this, taking a bend to the west and then to the south, it traversed Poland, Prussia, and Germany by a peculiar and well-marked route, until it reached England and the north of France, and, at a later period, Portugal, Spain, the south of France and Italy; thus taking, from the borders of the Caspian Sea, the contrary course to that pursued by the preceding disease. This circumstance is the more remarkable, inasmuch as the disease had reached, by another branch, or offset, the eastern and southern shores of the Mediterranean as early as the year 1823; and Egypt, in 1831; whence it

perhaps, as a Siberian plague, that, five centuries ago, the Black Death came to England." * This conclusion is not only contrary to fact, but it is, at the same time, a singular one, coming from a writer in Mr. Simon's position, and who, we might have concluded, would, at all events, have been acquainted with the history of diseases, if not with their causes. Independently of the fact, that the plague travelled from England to Russia, at that period, *not* from Russia to England, the Siberian plague is a totally different disease to the Black Death!

[4] Whether the line thus traversed be volcanic, will be considered more particularly hereafter: it is sufficient now to remark, that, if it be, the line must be a new one; no indication of volcanic action having been observed previously, in several of the countries passed over by the epidemic.

* 8th Report, page 26.

threatened the isle of Cyprus on one side, and Greece and Italy on the other. These countries, however, entirely escaped at that period, while they were subsequently invaded in another and opposite direction, thus proving, most satisfactorily, that this epidemic, like most others, pursues its own peculiar and well-marked course, independently of human assistance, and, apparently, against the stream of commercial intercourse. The epidemic spread, at the same time, from its first point of departure, Jessore, in the opposite direction, having extended to Sumatra, Java, Burmah, Manilla, and China, apparently over the old volcanic band of the Sunda and Molucca Islands.

The same law has been found to hold good with epizootic diseases, which have invariably progressed along the same line of route as the diseases of the human race. This was the case during the last pestilential epoch, with all the epizootics of which we have any record; for they progressed regularly from east to west, like the black death, or the plague, across the continent of Asia and Europe. Not that this law is invariably observed, as diseases—both epidemic and epizootic—like earthquakes, are sometimes progressive, sometimes local. When, however, they do pass from one country or region to another, it is invariably along the same lines of the terrestrial sphere. The bovine maladies of the present pestilential epoch—such as the foot-and-mouth disease, pleuro-pneumonia, and the cattle plague—have obeyed the same law.

A complete history of the foot-and-mouth disease is wanting: we only know, that it prevailed on the Continent previously to its appearance in England in 1839, while it has been recognized in India. As, however, the

cattle in India are not numerous, and their flesh rarely employed as food, it did not attract attention until lately. There can be little doubt, however, that it sprang up there soon after the appearance of the epidemic cholera, for such has been the case in Europe. Although we have accounts of the prevalence of a similar disease during the last pestilential epoch; and although isolated, or sporadic, outbreaks occurred in a few instances, at the end of the last and beginning of the present century, it did not appear in an epidemic form, until about the period of the first outbreak of cholera in Europe. The first account we have of it is in 1834, when it was prevalent in Hungary, Lower Austria, Bohemia, Saxony, and Prussia. In 1837, it appeared in the Vosges, a chain of mountains to the north east of France, and in Switzerland. Thence, it extended over France and Holland to England, which it reached in 1839, as, also, Ireland. We have a more accurate account of pleuro-pneumonia, which, according to the report of Mr. Vice-Consul Blackwood, commenced in the steppes of Southern Russia soon after the appearance there of the epidemic cholera: but it existed, in all probability, some years previously, although not generally perhaps: having appeared at Dantzic as early as 1821, in Belgium in 1828, the Rhine Provinces in 1830, and at Brandenburg in 1832. Be this as it may, as soon as the disease assumed an epidemic form, it spread from the south to the north of Russia, and thence through Poland, Prussia, and Mecklenburg, to Holstein. It also appeared, at the same time, if not previously, in Ireland, as the Census Commissioners for Ireland, in their Report, under date 1839, remark: "The epizootic of pleuro-pneumonia among cattle, which has spread so

extensively over Europe, for some time anterior to this date, now raged in Ireland." We have no account of the prevalence of this disease beyond the steppes of Russia, as details would be wanting in the countries between Russia and India; while we could hardly expect to meet with pleuro-pneumonia in India, it being, like ordinary inflammation of the lungs, an affection of cold rather than of warm climates. That atmospherical or local causes have some influence in its production, may be inferred from the fact, that this disease and "eczema epizootica" appear to be only different forms of the same disease, for the one is sometimes found to terminate in the other. Referring to the prevalence of the foot-and-mouth disease, in 1841, in Ireland, Dr. Jackson remarks: "It was a pleuro-pneumonia to all intents and purposes, divisible into two stages—primary and secondary. In the first, there was ulceration of the feet, lining membrane of the mouth, nose, &c. . . . In the secondary form of the distemper, we had inflammation of the pleura and lungs."[5]

The next epizootic that appeared was rinderpest, a foolish name, as it is merely the German for "cattle plague"—a term that will apply to any other bovine disease the same as this. Fortunately, we have more accurate accounts of this plague; and are, therefore, enabled to trace it from its first origin to its termination. It is stated, and has been repeated, *usque ad nauseam*, that the steppes of Russia are the home of rinderpest, although nothing can be more erroneous than such an opinion. We accuse the Russians of propagating the disease: they state that it was imported from Asia Minor, which means,

[5] *Report of Cork Street Hospital.*

that it prevailed there previously. This, no doubt, is the fact, for we have proof that it has prevailed in India since 1818—the year after the first appearance of the epidemic cholera—but there is no proof of its prevalence in Russia until 1828; being nearly coincident with the outbreak of cholera in that country. That rinderpest has prevailed in India from 1818 to the present time, there is abundant evidence to prove, as it appeared in Assam before its occupation by the British, in 1824. From the account given to Veterinary Surgeon Farrell, it appears, that a plague broke out in 1818, amongst the army cattle of the Burmese, who had invaded Assam. It destroyed them all, and spread into the country, committing great devastation. There was another visitation, in 1825, and a third, in 1830; but the particulars are wanting. Again, Dr. Gilchrist affirmed, that the *burra azar* of Madras is identical with *rinderpest*.[6] Colonel Campbell also states: "In 1849, plague attacked cattle at Tezpore, and so many died that it was impossible to remove them." Another visitation was experienced in Assam, in 1852-3, the loss being estimated by Mr. Grote, the Secretary to the Board of Revenue, at 120,000 cattle. It appeared again in 1854-5, since which it has prevailed, periodically, in the district. In 1860, deer, and other wild animals, were found dead in the jungle with the same pathological appearances. The Commissioners, appointed to inquire into the subject, state, that no doubt exists of its having been *rinderpest;* and they add, "no case of recovery was heard of." Rinderpest broke out, also, among the cattle during a "cattle show," held in Calcutta, in 1864. Referring to this outbreak,

[6] *Practical Treatise*, 1848.

Dr. Palmer remarks: "Sufficient has, we think, been advanced to prove the existence, very extensively throughout India, of two distinct and very fatal epizootics: the one we believe to be identical with the 'eczema epizootica,' or 'aphthous epizootic' or 'foot-and-mouth disease' of England: the other is identical with the Calcutta epizootic of 1864, or rinderpest."[7] Lastly, Mr. T. P. Gudgin, Veterinary Surgeon, 2nd Dragoon Guards, who witnessed an epizootic, that prevailed in Burmah in 1864-5, pronounces it to have been rinderpest; and he sets down the loss at 100,000, although the disease had not then terminated. Instead of the steppes of Russia being the home of rinderpest, it is the plains of India, if the place in which it first appears is to be called its home. It is impossible to trace its course from India to Russia, from the absence of information, and from the fact, that the prevalence of epizootics in those regions would have excited little attention in Europe at that time. But, that the cattle along the line of route taken by the epidemic cholera, through Asia Minor and Persia, were also attacked by disease; and that it prevailed there before it appeared in Russia, we may be certain, not only from the circumstance before mentioned—viz. that the Russians consider rinderpest to have come from Asia—but, also, because this disease has been the almost invariable accompaniment of the epidemic cholera in all other regions.[8] This conclusion would seem to be confirmed

[7] *Report to the Secretary of the Bengal Government*, 1871.

[8] It will be my object to show in writing on Epizootics, that rinderpest, although considered to be a form of typhus, similar to that of the last pestilential epoch, has no analogy with that disease.

by another circumstance. During the recent outbreaks of plague in Asia Minor and Persia, epizootics have prevailed at the same time. In fact, Dr. Rossi, inspector of quarantine at Erzeroom, attributed the manifestation of the plague at Maku—a town in the north-west of Persia, on the Turco-Persian frontier—to the severe murrain that had prevailed previously. Unfortunately, the course of the disease from the south of Russia to England has been precisely that of the ordinary route of cattle, and this circumstance has afforded the contagionists one of their strongest arguments. But it does not hold good in other instances, for there is no importation of cattle into Asia Minor or into Russia; and yet, as we have seen, the disease sprung up in India many years before it appeared in Russia, and must, therefore, have passed across the intermediate regions. Then, again, rinderpest spread at the same time, in the opposite direction, or from west to east, for it has existed in China for many years; although from the want of communication with the interior of that country, its existence was not known until recently. It was first noticed at Shanghai in 1868, by Dr. Thin, who remarks in a letter addressed to the *North China Daily News*, that the disease was considered by the natives to be "Ma Ping" (blood disease). It was, they added, of common occurrence. Dr. Henderson, who also observed the disease at the same time, states, in his report, that "he believes it to be as truly endemic (epidemic?) in the great plain of

It is merely a modified form of cholera. We need not be surprised, therefore, to find, that it has so constantly accompanied and followed the former disease.

China as in the steppes of Russia."[9] As this murrain is, like the epidemic cholera, a new disease—and, as remarked before, distinct from the murrains that prevailed during the last pestilential epoch—we may presume that it sprung up in China, the same as in India, after the appearance of the epidemic cholera, which, as may be remembered, spread not only to the north, but also, by another line, to the south-east, as far as China. More than this, we may be certain that it sprang up there spontaneously, as no cattle are imported into China from India. It is thus evident, that epizootic diseases have sprung up simultaneously with those in the human race, have obeyed the same laws, and have progressed along the same well-defined and peculiar line of the earth's surface. There is only one exception to this rule: the rinderpest has not yet made its appearance in America. But it will do so, some day, in spite of quarantine, and the intervening sea, and for the simple reason, that the same morbific line has passed across that continent; as we have proof by the spread of the epidemic cholera, and by the appearance there of eczema epizootica, pleuro-pneumonia, and influenza.

This progressiveness is not confined to great pestilences, like the preceding, and those reputed to be contagious: other diseases of a comparatively mild form, and universally allowed not to be infectious, exhibit the same phenomenon, and in a more marked degree. This is the case with influenza, which has preceded, accompanied or followed, all the great pestilences of which we have any record. The accounts respecting the exact course of this disease, during the first part of the late pestilential epoch,

[9] *Customs Gazette of Shanghai*, January to March, 1872.

are necessarily meagre and imperfect; but in 1510, influenza spread from Malta to Sicily, Spain, France, Great Britain, and the north of Europe, thus pursuing, so far, the exact route of the plague or black death.[1] In all probability, it had spread previously from Asia to Europe, as was usually the case. Thus, the influenza of 1557 commenced in Asia, and then passed, with great rapidity, to Constantinople, and thence over Europe by the route already described. It also spread to the continent of America, the first notice we have of the prevalence of such a disease in that country. The next visitation, that of 1580, followed the same course, viz., from east to west, and from south to north. The same disease continued to return, from time to time, until the termination of the last pestilential epoch; eight visitations having been recorded by different writers during the last century—the first in 1709, and the last in 1782. There was a slight visitation in England in 1803; but no other until 1832, a year after the outbreak of cholera. It might be concluded, that this was the first visitation of influenza, of the present pestilential epoch; but I should be inclined to refer the influenza of 1782 to the present, not the past period, and for this reason—its route was different. Instead of proceeding from east to west, and from south to north, it pursued the opposite course, from its origin in China, viz, from south to north, and from east to west, having, after reaching Russia, passed through Denmark and Holland to England. It thus traversed precisely the same line as that subsequently pursued by the epi-

[1] This was the first recorded visitation of influenza in England; but, according to the "Annals of the Four Masters," it was epidemic in Ireland in the 14th century.

demic cholera, and all the general influenzas that have followed in its train. We may therefore infer, that the morbific line, previously described, had been formed some years before the first appearance of the epidemic cholera in Bengal, in 1817.

The next influenza that appeared was in 1830-31. Like the former, it commenced in China, having broken out on board the E.I. Co.'s ship *Inglis*, on the 25th of January, 1830 : on which day eight men were attacked, twenty-four on the 26th, ten on the following day, and six on the 28th. The disease, *within two hours*, was as severe as at any time during its continuance. The epidemic then spread across the continent of Asia to Russia, Germany, England, and France, where it arrived in the autumn of 1831, having thus taken rather more than a year to traverse the whole of the route. Horses were affected at the same time. In 1833, influenza, or *grippe* as it is termed in France, sprung up suddenly in Russia, and then spread through Poland, Germany, and Holland to England—men and horses being simultaneously attacked, the same as in the former visitation. Whole families were struck down suddenly, and whole populations in the course of a few days. At Memel, 8000, out of a population of 10,000, were suffering at the same time. In St. Petersburg, there were, it was calculated, 100,000 persons attacked almost simultaneously, and 500,000, or about a fourth of the population in London. Some districts, in the line of route, were entirely spared, or only partially invaded.

Sometimes, influenza is confined to the brute creation, the same as other diseases.[2] This was the case in 1841,

[2] "Cows and horses have especially suffered from influenza, as

when influenza appeared in the north of Europe, and then spread through Bohemia, Prussia, Holland, England, France, Spain, and Portugal, attacking all the cattle on the line of its march, with almost railroad rapidity. A more recent example has been afforded, by what has been termed the American Horse Distemper, or influenza. It first appeared at Toronto, on the 20th of September, 1872, and then spread to Buffalo, Rochester, and other towns on the Canadian frontier. From this point it passed, in a southerly direction, through the Eastern States of North America—Boston, Jersey City, New York, Keene, Philadelphia, Chicago, Washington, Oswego, and Baltimore being attacked in rapid succession. It reached Galveston, Texas, and Pensacola (Florida) the end of November, thus taking two months to traverse the line from Toronto, in Canada, to the southern part of the United States. This is a longer time than influenzas generally take to spread over a similar extent of country, which may be accounted for, perhaps, by the peculiarity of the disease. Dr. Fricke concluded, that the epidemic was more virulent than ordinary influenzas, and, from the anatomical lesions presented after death, that it is closely allied to the epidemics of diphtheria in the human subject.[3] The writer adds that, out of 30,000 horses in Philadelphia, above 2250 died in the course of three

was observed in the epidemics of 1733–37, and –43. Dogs, cats, deer, sheep, and swine, have not enjoyed any immunity; poultry, also, and even fish, seemed occasionally to be affected by the morbid influence."*

[3] *Philadelphia Medical Times.*

* *Annals of Influenza.* By Dr. Theophilus Thompson. London, 1852. P. 375.

weeks. No horse, it is stated, on the line of march of the malady, whether in town or in country, escaped. In order to show how this disease, like others, pursues its own peculiar course, irrespective of accidental circumstances or human intercourse, we may refer to the influenza that appeared in 1837. As may be remembered, the epidemic cholera spread from England to France, Portugal, Spain, and Italy, being the reverse course to that pursued by the black death or plague. This was the case, also, with the influenza just referred to. In January, it appeared on board the ships of war at Sheerness; in February, in the ships and in the towns on the north coast of Spain; in March, on the south coast of Spain; in April, at Gibraltar; and in May, at Malta and in the English Mediterranean fleet.[4] It thus pursued the opposite course to that taken by the influenzas and other diseases of the last pestilential epoch.

LAW II. ANOTHER LAW, CHARACTERISTIC OF THESE DIFFERENT PHENOMENA, IS THE REGULARITY OF THEIR PROGRESS, BOTH CHRONOLOGICALLY AND GEOGRAPHICALLY.

Although this rule is not so evident with regard to the formation of volcanic vents, on account of the want of historical data, in such instances, their production being frequently the work of ages, it is yet sufficiently clear to cause it to be set down as one of the laws of volcanic action; the vents along a particular line not being formed at once, but in succession. It is, however, from the minor effects of the same cause, that we have the best evidence of the progressiveness of volcanic action. Thus, earthquakes are sometimes observed to commence

[4] *Statistical Report of the Royal Navy*, 1837-3.

in one particular spot, and then to extend, regularly and slowly, over some considerable portion of the earth's sphere. A memorable example of this was afforded at the time of the appearance of the black death; when severe and remarkable concussions of the earth occurred in China, and thence extended through Asia Minor to Europe. It is only at a certain epoch, however, that this phenomenon is observed: at a later period of the volcanic process, earthquakes occur at particular, although sometimes extensive, points of the volcanic line; and sometimes at one point, sometimes at another.

With respect to diseases, the regularity of their progress is such, that their appearance, in a particular spot, has been predicted with accuracy long before the expected period. Thus Dr. Hecker, narrating the particulars of the breaking out of the black death in different parts of Europe, remarks: "The precise days of its irruption in the individual towns are no longer to be ascertained; *but it was not simultaneous;* for in Florence the disease appeared in the beginning of April; in Cessena, the 1st of June; *and place after place* was attacked throughout the whole year: so that the plague, after it had passed through the whole of France and Germany (where, however, it did not make its appearance until the following year), did not break out till August in England; where it advanced so gradually, that a period of three months elapsed before it reached London. The northern kingdoms were not attacked until 1349—almost two years after its irruption in Avignon; and in Russia it did not make its appearance until 1351—more than three years after it had broken out in Constantinople." (*Loc. cit.*, p. 50.)

The same law has been found to hold good with respect to the epidemic cholera, for it progressed with great regularity from the peninsula of India to the shores of America. In consequence, however, of the numerous observations, that have been collected from different quarters of the globe during the prevalence of this disease, we are enabled to add, what was not before ascertained or noted, in all probability, viz.—that although its rate of progression was exceedingly regular in a particular country, or region, it has varied much in different situations. Thus, after leaving the Delta of the Ganges, its rate of travelling was very uniform across the whole of the peninsula of India,—along the northern coast it was about a degree a month. But, although it only took a year to traverse the distance from Calcutta to Bombay, it was seven years extending from the southern part of Persia to the northern shores of the Caspian Sea, through the mountainous regions of the Caucasus; while, in Russia, it traversed the immense distance of 700 leagues, from the borders of the Caspian Sea to the shores of the Baltic, in the short space of six months. Notwithstanding this difference in different localities, its rate of progression, in the same country, or district, and in different countries, *characterized by the same geological features*, was singularly uniform; of which any one may convince himself by referring to the date of its arrival in each successive town, in the various portions of the globe visited by the disease. Moreau de Jonnes states that, in 1832, the degree of rapidity with which the disease spread in different directions in France, was as follows. "Cholera appeared in Calais on the 15th March, 1832, and broke out at Arles on the 17th

September following; having thus, in 186 days, traversed 200 leagues, forming the great diameter of France from north to south. The disease was recognized in Paris on the 24th March, 8 days after its appearance at Calais. On the 27th April, it had spread, by contiguity, to the Department of the Moselle; and, on the 11th May, to that of Finisterre, taking 35 days to reach the eastern, and 50 days to reach the western frontier of France;—having traversed, on the one side, 70 leagues, and, on the other, 120. Thus, the cholera traversed the territory of the kingdom (of France) from north to south *at the rate of one league in 24 hours;* whilst, from east to west, it required but 85 days to travel a distance of 190 leagues; which gives a rapidity of speed greater by one half."[5] It is also evident, from what has gone before, that the rate of travelling of influenza is nearly the same, not only during different visitations at the same period, but, also, at different and distant epochs.

The same law is apparent with the diseases of the brute creation. The memorable murrain of the 17th century, which has been described by Dr. Winklan, commenced on the borders of Asia, and then travelled, slowly and regularly, across the continent of Europe, from east to west. Its rate of travelling was fourteen *miles an hour,* and country after country, and district after district, were attacked in succession—the disease never appearing in very distant places at the same time, or continuing its ravages in one spot beyond a certain period. No cattle on *the line* of its march escaped: those that were within doors fell ill at the same time, and in the same manner, as those in the open fields. Yet

[5] *Lancet,* vol. i., 1832-3, p. 698.

the lateral boundaries of the disease were well defined and very limited.[6]

But, what is still more singular, is the fact, that the rate of progression of a particular epidemic, along the same line, or portion of a line, is nearly the same at different visitations. This is shown in the following Table.

TABLE B.—*Date of the appearance of Cholera, at the undermentioned places at two different periods.*

	1832	1834
Quebec	8th June	7th June
Montreal (180 miles from Quebec)	10th ,,	11th ,,
Kingston (190 miles from Montreal) ...	16th ,,	26th ,,
Toronto (184 miles from Kingston)	28th ,,	30th ,,

Here, there was a variation of *three* days only, in a march of between 500 and 600 miles.—Accident could not have produced such a result: while the stream of human intercourse is never so regular and so unvarying. This is more particularly apparent in the following instance. Dr. Cunningham, referring to the spread of cholera in India, states, that the epidemic does not travel more rapidly since the railways have been constructed than it did before, notwithstanding the difference in the rate of travelling of the population. Thus, the epidemic, in 1861, commenced in Cawnpore in May, and reached Mecan Meer on the 2nd August. It broke out again, in 1872, in the same town, and in *the same month,* and reached Mecan Meer on the 31st July, a difference of only two days.[7]

[6] *Philos. Trans*, vol. xiii., p. 93, A.D. 1683.

[7] *Ninth Report of the Sanitary Commissioner for India*, p. 16.

There is another circumstance well worthy of attention, in considering the rate of progression of these different diseases; this is, that their progress along the whole track pursued by them, although varying so much in different situations, appears to be about the same, when different epidemics are compared together. Thus, the black death took fourteen years to reach the confines of Europe, having commenced in China in the year 1333, and having broken out in Constantinople in 1347. From this point it gradually spread, by the route before described, to the northern parts of Europe, which it reached in 1351, or four years after its appearance in Constantinople. Now it so happens, that the epidemic cholera was exactly twelve years travelling from the extremity of India to the confines of Europe; having commenced in Bengal in the year 1817, and having broken out in Astrakan in 1829; it did not spread, however, beyond this locality until the following year. Although the disease from this point pursued a different route to that taken by the black death—as it visited the northern kingdoms of Europe first, and the southern last—it is a remarkable fact that this epidemic took about the same time to perform this circuit that the former did to complete the other route; for the cholera appeared in the countries bordering on the Mediterranean five years after its commencement in Astrakan, on the borders of the Caspian Sea—a difference of only one year. Such facts would be perfect anomalies, and altogether inexplicable, when viewed by the doctrine of contagion, as no reason can possibly be given, why the disease should have been propagated as speedily in the one case as in the other; for the commercial traffic and intercourse in the whole

of these countries, must have been widely different in the 14th and in the 19th centuries; independently of the fact that the routes are not the same, or the intercourse either, for the commercial traffic between the South of Europe and Constantinople and Egypt was altogether insignificant in the 14th century. And yet, although this traffic is now so great and so constant, the epidemic cholera invaded Europe by a route along which there is scarcely any traffic or commercial intercourse.

LAW III. THE NEXT LAW, REGULATING SUBTERRANEAN ACTION, IS, THAT ITS EFFECTS ARE GREATER ON TERTIARY THAN ON SECONDARY STRATA; WHILE THEY ARE SELDOM WITNESSED ON PRIMARY FORMATIONS.

Thus, the most common effect of volcanic action, the earthquake, occurs in general on tertiary formations, while the shocks are felt more severely in the deltas, and alluvial tracts at the mouths of rivers. It is also observed on secondary formations: but its effects are then more limited; while, on primary formations, concussions are slight, and almost unknown. The more rare effect of this action, viz. the volcano, is, on the contrary, generally observed on secondary strata; and is seldom found either on tertiary or primary formations; there being only one exception to this rule, viz. the volcanos of Chili.

The same law applies, with equal force, to the march of epidemic diseases. Like the effects of subterranean action, they are most prevalent on tertiary formations, less so on secondary strata, and very rare on primary formations. According to M. Lombard, the plague has never appeared at an elevation above 600 metres: and he cites the instance of Alem-Daghi, a village near to

Constantinople, situated 500 metres above the level of the sea; to which place the inhabitants of this city are in the habit of flying, during visitations of the plague—some of them with the disease upon them—yet it never spreads.[8] There are, also, other situations, as those near to *Safi*, in the island of Malta, and the citadel at Cairo, which have hitherto been exempt from the plague. The same law is apparent with respect to the prevalence and spread of yellow fever. Humboldt remarked, long since, that yellow fever, although so prevalent in the plains below, is unknown in the city of Mexico, situated at an elevation of 5000 feet. The limit of its range is, however, much less than this. "Dr. Toner, President of the American Medical Association, Washington, has contributed a paper on the distribution of yellow fever, which is published in a report issued by Dr. Woodworth, Supervising Surgeon of the United States Marine Hospital Service. Dr. Toner quotes authorities which show, that this disease has never been known in any climate at an elevation of 2500 feet. Mount Desmoulin, near Rousseau, in the island of Dominica, 1500 feet above the sea, is always free from fever, even when it is epidemic at the water-line. The same exemption is observed in the northern and elevated parts of San Domingo, whatever may be the character of the soil. Fort Smith, in Arkansas, 460 feet above the sea, is the highest point at which this fever has prevailed as an epidemic in the United States. Although Winchester, Virginia, at an altitude of 700 feet, is reported to have been visited by this disease, in 1802, the cases recorded are not well authenticated. The late Dr. La Roche,

[8] *Les Climats des Montagnes.*

noticed that a stranger might live securely in the near vicinity of the epidemic, provided he did not actually enter the infected district. It is clear, that the disease has, in the United States, never, in an epidemic form, reached an elevation of 500 feet."[9] In the West Indies, its range is greater, having been observed at Newcastle, Jamaica, and other localities, situated at an elevation of between 1000 and 2000 feet. But it never prevails in a very severe form in such localities, while the disease is always limited in its range. Like the plague, yellow fever, when imported, does not spread in such situations. Dr. Smith states, that, "when persons infected with this (yellow) fever arrived in the city of Arequipa (7850 feet high) from the seaport Islay, many of them died with black vomit; but, in each separate case, the germ of the disease seemed to have died with the individual."[1]

Numerous examples of the same kind have been afforded during the prevalence of the epidemic cholera. We are informed by Dr. Henderson, that the 19th Regiment of Infantry, to which he was attached, together with the 38th and 48th, encamped on a low marshy spot, near to Patnago, in 1825: in the morning, one officer was attacked with cholera, and, in twenty-four hours, twenty men were carried off. On the following day, the corps removed to a higher ground, a mile and a half off: and, from this time, no more cases of cholera were observed. Another example, but on a larger scale, was afforded by the army of the Marquis of Hastings, which was attacked with cholera in Bundelkund, during the first year of the prevalence of

[9] *The Medical Times and Gazette*, May 16, 1874.

[1] *The Dublin Quarterly Journal of Medical Science*, May, 1866. p. 348.

the epidemic. This division of the grand army had encamped on the banks of the Sind, immediately after which the epidemic appeared: commencing, in its usual insidious manner, by attacking only the lowest orders of the camp-followers. But, in a few days, and as it were in an instant, the disease burst forth with irresistible violence. "Unsubjected to the laws of contact, and proximity of situation," to quote the language of the Bengal Report, "which have been observed to mark and retard the course of other pestilences; it surpassed the plague in the width of its range, and outstripped the most fatal disease, hitherto seen, in the destructive rapidity of its progress. In the course of a week, it had overspread every part of the camp, sparing neither age or sex, in the undistinguishing virulence of its attacks—the old and the young, the European and the native, fighting-men and camp-followers, were alike subjected to its visits; and all sunk, in a few hours, under its most powerful grasp. It was then wisely resolved, by the commander-in-chief, to change the encampment, in search of a purer air, and a healthier soil: and although the line of march was covered with the dead and the dying—men dropping from their horses, or falling while marching in the ranks, as if struck by a cannon-ball—they succeeded, after a few intermediate halts, in reaching on the 19th, the high and dry banks of the Betwah, at Erich; where they *almost immediately got rid of the disease*, for not a severe case occurred after the 22nd." Now, although it must be confessed, that many of the mountainous tracts, which then escaped, have since been ravaged by the disease, yet it might be seen, even in these instances, as Mr. Jameson remarks, that high lands were not congenial to it; for

the epidemic was generally raging with great violence on the plains below, at the very time that the hilly and mountainous tracts were only slightly affected by the malady. Although the cholera subsequently ascended to some of the highest inhabited ranges of the Himalaya mountains, the outbreaks have been few in number, and the disease limited in its range. "Kussowlie, in the Himalaya range," says Dr. Cunningham, "is only nine miles from the plains, with which there is constant communication; and yet, for the twenty-eight years, from 1845 to 1872, there is no record of any outbreak of cholera at Kussowlie. With the exception of 1867, when the disease was chiefly confined to the native servants, the oldest inhabitant cannot remember the occurrence of cholera at Simla, excepting in a few isolated cases; and, with these, the disease was imbibed in another locality (*Loc. cit.*). But, although ascending this primitive range, the epidemic was never able to cross this barrier; as it was by another and a different route that this *nova pestis* reached Asia Minor and Europe.[2] The greater prevalence of these diseases on tertiary strata, in alluvial tracts, and on the deltas of rivers, is so generally and so well known, that writers of various and different opinions have ascribed the origin of these complaints to malaria, or some other poison, generated in such situations; being afterwards propagated by particular channels or certain means, as contagion, to other and distant parts of the globe. But such a conclusion, for the reasons already given, will not hold good, while it is negatived by the fact, that the removal of the sick and the healthy to more elevated situations has generally

[2] See Map 1, in Appendix.

been found sufficient to arrest the progress of the disease; and this too when intercommuion between the sick, or the refugees, and the residents was free and uninterrupted.

With regard to the difference, which the disease exhibited in different localities, we may refer for an example, on a large scale, to the mountainous regions of Persia and the Caucasus, and the vast plains and alluvial districts of Russia. It was in 1821, that the disease first attacked the towns situated on both sides of the Persian Gulf, whence it spread, slowly and gradually, by the route already mentioned to the southern shores of the Caspian Sea; which it reached in 1823. But there was a striking diminution in the velocity, as well as in the extension of the malady, as it proceeded northward, and gained the defiles and mountainous tracts of the Caucasus, having taken seven years to traverse this region, proceeding step by step, and year by year, from one extremity of the mountain range to the other. This circumstance cannot be ascribed to the paucity of the inhabitants in these districts, for the malady extended, at the same time, to the large and populous town of Astrakan, where the visitation was as circumscribed, and subsided as quickly as in other and more thinly inhabited regions. The malady continued to prevail every summer, to a slight extent, in the north of Persia, and on the southern borders of the Caspian Sea, until the year 1830: when, having apparently gained fresh strength, it suddenly extended in a northerly direction, and a second time attacked Astrakan. After cutting off 4000 persons in the town, and 21,000 in the province, the epidemic proceeded with unprecedented velocity

through the heart of the Russian dominions, committing great havoc among all classes of the natives, *in the thinly inhabited districts* as well as in the most populous. In the spring of the following year, it again reappeared, and then spread through Poland and Germany with inconceivable rapidity; having reached Berlin in August, and Hamburg in October.

By a reference to any geological map of Europe—as that in the *Encyclopædia Metropolitana*—it will be seen, that the tract of country traversed by the epidemic, with such rapidity, forms one single and immense tertiary deposit; being bounded to the west and south by a chain of primary mountains through a great part of its extent. This barrier, here as elsewhere, was sufficient to prevent the spread of the disease in that direction; for although extending along the whole of this plain from south to north, the disease was not seen on the western side of this range of mountains. One exception occurs to the above, and this is the kingdom of Austria, which is situated to the west of these mountains. But, then, it will be seen, that the district thus referred to is not situated on primary formations; as a tract of country, extending from the Black Sea as far as Vienna—and which is somewhat broad at the base, or to the east, and narrow at the apex, or towards the west—is marked in the map as tertiary. Now it was precisely over this tract of country that the disease spread; for the epidemic, after reaching the borders of the Caspian Sea, proceeded in two different directions—one by the route before described, and another by the northern borders of the Black Sea, to the mouth of the Danube, along whose banks it extended as high up as Vienna. But, although the

disease had thus reached the boundaries of Switzerland, this country continued free, for the epidemic did not spread any further in this direction. Switzerland, it is true, although spared during the first visitations of the cholera in Europe, has since been invaded by the disease; but it was in another and the opposite direction, by the opening on the western side of the mountains, and by the extension of the disease through the alluvial plains of France. Even this was not effected, until after the lapse of many years: while "the small mortality," as M. Lombard remarks, "which occurred, authorizes the conclusion, that elevated plains and mountainous regions are not favourable to the development of the epidemic cholera." (*Loc. cit.*) Nothing can show the influence of locality, on the propagation of epidemic diseases, more forcibly than these facts.

The same law will be found to hold good with respect to the diseases of the brute creation. De Berg states, that the epidemic murrain of the last pestilential epoch was more prevalent in the lowlands than in the highlands:[3]—an exemption that was remarked in England, during the severe epizootic of 1745-57; the whole of Wales, with the exception of Montgomeryshire, having escaped the ravages of the disease. According to Haubner, the "trembling disease" of sheep prevails principally in low, damp, alluvial soils, and in valleys surrounded with mountains. Although the flocks have been renewed again and again, the disease has continued to return; and has only been arrested by the removal of the flocks to other and higher regions. Rot is another disease peculiar to low plains, being seldom met with in

[3] *Mémoire sur le Typhus*, 1776.

elevated regions; and the same may be said of ovine small-pox. This law has been, if not better observed, more clearly demonstrated during the prevalence of the present epizootic, or rinderpest. Not only did it commence in the low, alluvial plains of Russia, on its first appearance in Europe, but it has continued to prevail there and in similar situations—not exclusively but principally—up to the present time. Thus, it spread, at an early period, to the south of the Carpathian mountains, over the tertiary formation before referred to, on which Austria, Hungary, and Moldavia are situated. But it was unable to pass the mountains of Switzerland, the Tyrol and Upper Moravia, which thus appeared to stand like a wall between the disease and western Europe. So, again, it has never penetrated the mountainous regions of the Balkan, or prevailed to any extent in the elevated districts of Transylvania—from 2000 to 8000 feet above the level of the sea,—or in those of Servia, Bosnia, and Bulgaria. It was by a different route, that the cattle plague reached the western part of Europe; by the alluvial plains of Russia, of Poland, Podolia, Wallachia, Silesia, Holland, and France—thus making a complete circuit before arriving at the western frontier of Switzerland, into which it penetrated in 1872—forty years after it had appeared on the eastern side of the Swiss mountains.[4] It reappeared in 1873, and committed considerable ravages; but the disease was confined to the lowlands. It is also worthy of remark, that Prussia, and the more elevated regions of Germany, although surrounded by the plague for many years,

[4] This, as will be evident, from what has gone before, is precisely the route that was taken by the epidemic cholera.

escaped the disease—or, at least, a serious visitation of it—until 1871. According to Renault, the steppe cattle remain exempt from rinderpest in the Upper Palatinate, and in Swabia: and other writers affirm, that it never prevails at an elevation above 500 feet. There are, however, exceptions to this; but the limitation of range of the disease is then very marked and slight.

We have observed the same results in England, it having been precisely on the low, alluvial, plains of Cheshire, Cambridgeshire, Huntingdonshire, &c., that the cattle plague committed its greatest ravages. On the other hand, there was not, with the exception of Denbighshire and Flintshire—the geological formation of which is somewhat different to that of the other eight counties—a single case on the primary mountains of Wales. But the ravages of the disease, in these two counties, were altogether insignificant, when compared with those on the plains below. This will be evident by a reference to the following Table.

TABLE C.—*Showing the number of cattle that were attacked and died, in the following counties in* 1865-6.

Counties	Total Cattle	Number attacked	Ditto killed	Died	Recovered	Healthy cattle killed
Cheshire ...	137,798[5]	93,376	38,618	40,851	13,907	4690
Flintshire	36,080[5]	9020	1261	6567	1192	326
Denbighshire	46,695[5]	4279	180	3487	608	395

It will thus be seen, that 67 per cent. of the cattle were attacked in Cheshire; while in Flintshire, according to the official returns, only 25 per cent. were attacked, and only 9 per cent. in Denbighshire. This result cannot be

[5] These were the numbers on the 5th March, 1866.

ascribed to the preventive measures adopted, for the pole-axe was used less freely in Wales than in Cheshire. In the latter county, 41 per cent. of the cattle attacked were slaughtered; in Flintshire, 13 per cent., and, in Denbighshire, only 4 per cent. And yet it was precisely in the last-named county, that the course of the disease, in this direction, was arrested. The county of Westmoreland, also, which, like Wales, is formed of Silurian rocks, remained almost entirely exempt, although actually hemmed in by the disease. In Scotland, the counties of Bute, Argyle, Banff, Elgin, Nairn, Ross, Cromarty, Sutherland, and Caithness—mostly situated on primary formations—escaped altogether, as, also, Orkney and the Shetland Isles. That these exemptions are to be referred to geological formation only, will be evident by a reference to the Table now added.

TABLE D.—*Showing the number of isolated outbreaks of cattle plague, in England and Wales, arranged according to geological formations.* [6]

Tertiary and post-tertiary formations	952
Chalk formations	400
Oolite „	268
Lias „	102
New red marl and sandstones	663
Magnesian limestone and Permian marl	120
Coal measures	402
Old red sandstone (Devonian)	59
Silurian	6
Cambrian rocks	0
Metamorphic rocks, quartz, &c.	12
Igneous rocks	5
Total	2,989

[6] *Report of the Veterinary Department of the Privy Council.* By A. W. Williams, L.R.C.P. (Ed.), M.R.C.S. (L). 1866.

Even when the disease does appear in mountainous regions, it will be found to prevail, less and less, the higher we ascend. Thus, its prevalence in Yorkshire was in an inverse ratio with the elevation; while it disappeared altogether at the height of 1000 feet. "In Yorkshire, 2000 farms were attacked, but as many of these were near to each other, the 'centres of infection' were only reckoned at 680. Of this number, 538 or 79·11 per cent. have occurred at an altitude not exceeding 250 feet: 98 or 14·41 per cent., at an altitude not exceeding 500 feet; 39 or 5·73 per cent., at one not exceeding 750 feet; 5 or ·73 per cent., between that height and 1000 feet; no case having occurred above this height." (*Loc. cit.*, p. 35.) The uplands of Wiltshire also escaped almost entirely—an exemption that occurred during the severe epizootic of 1745-57.[7]

Although usually exempt, epidemic diseases do occasionally break out, and prevail generally, in elevated and mountainous districts; in which case, the disease almost invariably presents a more severe and fatal form. It is the same with epizootics. This has been remarked by

[7] Notwithstanding these exemptions, and in localities actually surrounded by the disease, we have been told by the contagionists that the poison of cattle plague can not only be carried by birds and other animate things, from place to place, but even by the shoes and the stick of a pedestrian from John o' Groat's to Land's End! When will men cease to feign hypotheses, and learn to search for facts? At the commencement of the cattle plague, I published a *brochure*, and suggested that the animals, when attacked, should be removed to elevated situations. The veterinarians, however, rushed in with the pole-axe, and removed them, not to more healthy localities, but to a place where worms do grow, and flesh becomes corrupt!

Veith, who says that the cattle plague does occasionally break out in hilly districts, and that it is then more deadly.[8] Ampach also states, that he has observed this disease in mountainous districts; and that the disease was then, not only more active, but, also, more rapid in its course.[9] The cause of the variation, or exception, will be better understood hereafter.

LAW IV. ANOTHER LAW TO BE MENTIONED IS, THAT THE EFFECTS OF VOLCANIC ACTION ARE ALWAYS MUCH GREATER, AND MORE PERCEPTIBLE, NEAR THE SEA, LAKES, RIVERS, SPRINGS, &c.

Thus, the volcano is never witnessed except near the sea, or great inland collection of water. Even those volcanos which lie inland, says Lyell, form part of a chain of volcanic hills, and may be supposed to have a subterraneous communication with the extremities of the chain, or with those volcanos which are near the sea, or large masses of salt water. The neighbourhood of the sea, therefore, seems to be one of the conditions necessary for the ascent of lava to great heights. Again: Whenever an earthquake, for the volcano is entirely a local phenomenon, is experienced, the shocks are always more perceptible in the sea, in lakes, and springs, than on dry land, being frequently observed in the former when no effect has been perceptible in the latter. A memorable example of this was afforded during the great earthquake, which occurred at Lisbon in the latter part of the last century, when a wave was produced, that extended to the shores of England and Holland, as well as other places farther removed from the centre of concussion. But in-

[8] *Handbuch der Veterinärkunde.*

[9] *Praktische Lehre von den Heerde-Krankheiten*, &c. Pesth, 1819.

dependently of this effect in the waters of the ocean, which can be readily accounted for when it is known that a wave sixty feet high rose at Lisbon, similar disturbances were felt in the water of lakes, canals, and ponds, both in Holland and England,—situations altogether removed from any, or the least, communication with the sea. Thus, on the day when the above earthquake occurred, a surprising and frightful noise was heard at Bilborough, in Derbyshire, near a large body of water called Pilby Dam; and a swell, which came in a current from the south, rose two feet on the north side of the lake. At Loch Lomond, in Scotland, the water, without the least apparent cause, suddenly rose against the banks to some considerable height, and then as suddenly subsided far below its usual level. At Eaton Bridge, Kent, the water of a pond was observed to open in the middle, so that a post, *before covered with water*, could be seen a great way down, almost to the bottom. The same or similar phenomena occurred in many parts of England, and in various parts of the continent, even in the north of Germany, although the concussion itself did not extend far to the northward of Lisbon.

So frequently do epidemics make their appearance at the mouth of some river, and so invariably are they propagated along the banks of those streams, at whose mouths they appear, that this circumstance has afforded the advocates of the doctrine of contagion one of their strongest arguments; as it is generally in the course of rivers that commercial traffic and human intercourse are the greatest and the most regular. Thus, the epidemic cholera first broke out on the banks of the Ganges, and ascended by the course of this stream, for 400 leagues, to the interior

of India. It then attacked all the towns situated on the Jumna; and, from Allahabad, at the confluence of this river and the Ganges, it spread to the districts watered by the tributaries of these streams. Subsequently, it followed the course of the Brahmaputra, the Gogra, the Chambal, Betwa, and the Sind rivers. So, also, when it commenced its ravages on another continent, it proceeded, after attacking the towns on the borders of the Persian Gulf, by one route, slowly, and with apparent difficulty, through the arid tracts and mountainous regions of Persia, as far as the Caspian Sea; while it proceeded, by another route, with the greatest rapidity, along the banks of the Euphrates and Tigris to the Mediterranean. Again; when the disease reached Astrakan, it spread with unprecedented violence along the banks of the Volga, until it reached Moscow on the one hand and St. Petersburg on the other: traversing a distance of 550 leagues in little more than two months. Its progress was equally rapid on the Don: and no less so on the banks of the Dnieper: while it was along the banks of the Danube, that the epidemic proceeded towards Vienna, and ascended to the rest of the Austrian dominions. In England, also, the first cases that occurred were on the banks of the Tyne, the Humber, and the Thames. Precisely the same law was found to hold good in America. "It was in June, 1832," as we are informed by one writer, "that Asiatic cholera first made its appearance on the north-east coast of America, and spread, with fatal rapidity, along the great water-courses on our northern frontier. Whilst one branch of the epidemic passed down the Hudson to New York, another continued west along the great lakes, until, in September, it reached some of our military posts

on the Upper Mississippi. General Macomb says, that the cholera infected the troops on board the steamboats on their passage up the lakes: and such was the rapidity with which this disease spread among them, that, in a few days, the whole of the force sent by the lakes—to attack the Indians—was rendered incapable of taking the field. The loss by cholera, in that detachment alone, was equal to one out of every three men."[1]

It is worthy of observation, as showing the local origin of these diseases that, although prevailing most in tertiary formations, and although extending with greater rapidity in the course of rivers than in any other direction they have not always commenced at the mouth of these streams, or, at the point to which commerce and traffic happen to verge in that particular locality; notwithstanding that these situations were in the direct route, which the disease was pursuing, and notwithstanding that the towns, at first passed, were subsequently attacked. Thus, the plague of A.D. 252 began in Ethiopia, on the borders of Upper Egypt; Lower Egypt, and the towns on the sea-coast, being subsequently attacked. The same result was observed in 1736. The plague of 1348, also, as well as that of 1482, appeared first at Avignon, and afterwards at the ports and towns on the Southern Coast of France—the course of the disease being, not from north to south, but from south to north. Again: the first case that occurred in England was not at Sunderland, or any other part of the coast, but at some distance in the interior; while the individual, it was proved, could have had no communication with persons coming from an

[1] *American Journal of the Medical Sciences.* April, 1842.

infected spot. So, also, when the disease reached Russia in 1829, instead of commencing, as we should have concluded it would, in Astrakan, a large and populous town on the sea-coast, it broke out at Orenburg, situated on the banks of the Ural, 400 *miles* north of the Caspian. A similar phenomenon occurred in 1869, the cholera having broken out at Kïev, 200 miles inland, while Odessa, the port to which all the steamboats, on the Black Sea, converge, was not attacked until six months after. Every attempt to prove the importation of the disease into these places having failed, we must conclude, that when the malady reaches any alluvial tract, it selects that town, the situation of which is most exposed, and the best fitted, to receive the impression of the pestilential virus; no matter whether it be at the mouth of a river, or whether it be in daily communication with other and previously infected districts. The same result was observed with the cattle plague, which commenced in London, on the banks of the Thames, not on the coast, or at the places of disembarkation.

Next to the alluvial tracts and banks of rivers, epidemics have always prevailed most near inland collections of water, as lakes, ponds, &c., while their greater prevalence in the neighbourhood of particular springs, when compared to other situations, has doubtless given rise to the popular opinion so frequently, and we may say generally, entertained, during the prevalence of every epidemic, that such waters had been rendered deleterious by human agency.

LAW V. THE LAST LAW COMMON TO THESE DIFFERENT PHENOMENA, WHICH WE SHALL NOW CONSIDER, IS THEIR LIMITED DURATION; THEIR PERIODICAL RETURN; AND THEIR

TOTAL CESSATION, IN THAT PARTICULAR LOCALITY, AFTER CERTAIN DEFINITE PERIODS.

Thus, volcanos only throw out lava for a certain period, as a few days, weeks, or months, although the minor products of the same process, or aqueous vapour and gaseous substances, continue to be evolved for a much longer time, as several years. When, however, a vent has been once formed in any locality, eruptions are sure to be experienced from time to time, in the same spot, although the period of their return varies much in different situations. The same circumstance is observed with regard to earthquakes, except that they return more frequently, and at shorter intervals, than the eruptions of volcanos; for although the duration of a single shock is seldom more than a few minutes, still, a succession of shocks is sometimes felt, in the same spot, for many weeks or even months. They then subside entirely, for a period which varies under different circumstances, when they again return, and again subside, to reappear after another interval; for *the same continuous tracts*, as Lyell justly observes, are agitated again and again. In some situations, they are found to return at regular and fixed periods, or months in the year, more particularly in the summer season. When, however, these effects have continued for a certain period,—and, generally, a long period, many centuries—they are found to cease entirely in the district, or part of the globe, where they have been observed. It has been this circumstance, which has caused volcanos to be divided into active and extinct; or, those which are subject to occasional eruptions, and those which have not been observed to throw out lava or gaseous matter, during historical periods. Numerous

groups of the latter are scattered over the earth's surface the same as the former; in which situations, not only does the volcano remain in a quiescent state, but concussions and other signs of volcanic action are also wanting. This may be received as a proof, that the volcanic process is not permanent; but that it has its rise, fall, and total cessation, in each district, or spot, where it has prevailed.

The same phenomenon is characteristic of epidemic diseases, as they seldom prevail during one eruption for more than a few months—sometimes for only a few weeks or a few days—although we witness returns of these diseases for many years—generally for centuries—at regular or irregular periods. Thus, the plague or, as it was afterwards termed, the black death, broke out in the middle of the 6th century, continued to return at certain periods, and prevailed extensively in Europe, until the end of the 17th century. It then ceased, excepting in a few instances in the south of France, and in Russia, and in Turkey and Egypt, in which countries it will also cease, we have a right to assume, at no very distant epoch: unless plague, in common with other diseases, should again return, the new morbific line having crossed these countries also, although in a different direction. The epidemic cholera has followed the same law, excepting that we have, as yet, only witnessed its rise, not its decline or disappearance. Like the plague, it has continued to devastate the same tracts over which it first passed; while the period of its stay, at each visitation, would appear to have been about the same. According to M. Moreau de Jonnés, the longest period during which the epidemic cholera has continued in any

particular town, or locality, is 114 days, and the shortest 20. But its duration was even less than this in the east; in the upper provinces of India it seldom remained in a town or district more than 10 or 15 days. What the duration was of the black death in the east, we have no accounts; but, in the west, it seems to have remained during each visitation about the same period as the epidemic cholera, or, from 2 to 3 months.

The intervals, between the visitations of epidemic diseases, are generally shorter and more regular than the ordinary effects of volcanic action. The great pestilences would appear to return about every 10 years. This was near the interval of the appearance of the plague in Europe, in Asia, and in Egypt. Thus, there was a visitation of plague in Egypt in 1815, 1825, and 1835. The cholera years in England have been 1832–48–54, and 1866—the intervals being 16, 6, and 12 years.

Having thus shown, that the laws, which regulate the effects resulting from volcanic action, as manifested on the crust of the globe, and those which govern the duration and progress of pestilential, or epidemic, diseases, are similar, it follows, either that these various phenomena arise from two different causes, governed by the same laws; that the one set is an effect of the operation of the other; or, lastly, that they are common effects of a common cause. When we remark, however, that these effects are so various and dissimilar, it is difficult to conceive, how different causes could give rise to phenomena which, varying both in kind and degree, should observe exactly the same laws. That, on the other hand, the one set of phenomena is the cause of the production of the other, we might, at first sight, be induced to infer

from the remarkable fact, that epidemic diseases seldom prevail to any extent, or for any long period, without being accompanied by concussions of the earth. This circumstance has been particularly dwelt on by Noah Webster, who, in his *History of Epidemics*, says: "It has been ascertained, beyond all question, that the periods of extensive pestilence and mortality are remarkable for earthquakes and eruptions of volcanos. But the explosions," he adds, "do not so generally precede epidemics, as to authorize the supposition that they produce these diseases. Earthquakes occur during the prevalence of pestilential or other mortal epidemics, but generally in the midst of the period, sometimes at the conclusion." In fact, it more frequently happens, that the concussion occurs on the termination of the epidemic than at any other period—a circumstance that has been remarked by many writers. Thus Van Swietan says: "When the plague raged at Ockazon, on the very day the distemper began to abate a violent earthquake happened;" and he, at the same time, asks, "Did anything exhale from the earthquake antidotal to the contagion of the plague?"[2] Independently of the above, it does not always happen that earthquakes occur in the seat of pestilence, especially during the prevalence of general epidemics; as extensive tracts are frequently ravaged without such a phenomenon being observed. As it is clear, therefore, that earthquakes and volcanos cannot be the cause of the production of epidemic diseases, we must conclude, if there be any relation or connection between these different phenomena, that they are common

[2] *Commentaries*, vol. xvi. p. 36.

effects of a common cause, and that cause volcanic action. As such, it only remains to ascertain in what way these various effects are produced. In so doing, we unfortunately enter a wide field of conjecture and doubt, as no theory has yet been proposed, which appears, to the generality of geologists, to account for all the phenomena known to depend on volcanic action. It is impossible, therefore, to refer to any acknowledged theory, in order to account for the mode in which these several effects are produced; as might be the case, if we had clear and distinct notions of what volcanic action really is. Under these circumstances, all we can do is to state the different theories entertained on this subject, in order to ascertain if they will, either separately or collectively, account for the production of epidemic diseases.

Various theories have been proposed by different individuals, at different times, in order to elucidate the nature of volcanic action. In the opinion of many writers, all the phenomena known as volcanic are to be referred, the same as epidemic diseases, to the action of electricity. This is more particularly the case with Noah Webster, who remarks: "My own opinion, respecting the material system, is this; that an atmosphere, the basis of which is electricity, fills infinite space, and involves, in its bosom, all the solid orbs, which shine in the celestial region. This may be denominated the *mundane* atmosphere, in opposition to that of the *ether* of Newton." (*Loc. cit.*, vol. ii., p. 507.) To this mundane, or electric, atmosphere, Webster ascribes the influence which the moon exerts on the flux and reflux of the ocean: as, also, on the eruptions of volcanos and earthquakes. He adds: "The theory, which ascribes earthquakes to steam or vapour, appears

to be very unsatisfactory." . . . "There appears to be no way to account for the phenomenon, but by the great principle of action, *electricity!* Indeed, the discovery of the fact, that most earthquakes happen under particular phases of the *moon*, and that volcanic eruptions are obviously affected by her position in her orbit, seems to place this point beyond question." (Vol. ii., pp. 491 and 497.) "If we admit, then, the action of electricity to be the cause of earthquakes, we shall have reached the general proximate cause of those epidemic diseases, which speedily succeed concussions of the earth." (Vol. ii., p. 153.) Such conclusions hardly admit of a serious refutation. "Electrical phenomena," as Dr. Daubeny remarks, "are indeed common during the continuance of volcanic eruptions; produced, in all probability, by the evolution of large quantities of steam and other elastic fluids, the decomposition and subsequent regeneration of water, and other processes, that accompany these grand operations of nature."[3] The same arguments, in fact, that have been employed against the hypothesis, when applied to the production of epidemic diseases, will also apply to its reception, when broached in order to account for volcanic effects. We must seek, therefore, for another and a better theory. That which is termed the "Nebular hypothesis," is the one generally adopted by geologists; more especially as it is applied to the whole planetary system. Laplace, the originator of it, inferred, that the sun was originally a mass of incandescent matter, surrounded by a zone of vapour—somewhat like the rings of Saturn. This vapour being thrown off from the revolving mass by

[3] *On Active and Extinct Volcanos*, p. 524.

the centrifugal action, and expanded beyond the force of attraction, would, it was assumed, be separated, coalesce, and form distinct globes, revolving round the sun. Hence the origin of the planets, and hence the reason, why the earth is considered to be a globe of fire, in the act of cooling down. According to this hypothesis, the formation of the volcano is to be ascribed to secular refrigeration, or the slow diffusion of the primitive heat; for as, under such circumstances, the crust of the earth must contract, as it cools down, the pressure thus exerted, on the internal and fluid mass, would necessarily cause a portion of the melted matter to be ejected, from time to time, on the surface—hence eruptions and earthquakes. Another class of geologists, concluding with M. Houell, in his *Voyage Picturesque,* that fire cannot exist alone, and without any pabulum, have referred volcanic action to a species of combustion; and various substances, which were supposed to be adequate to the purpose, have been named—as sulphur, petroleum, and other inflammable matter. The third, and last, theory to be considered depends for its formation on the brilliant discoveries of Sir H. Davy, as to the chemical composition of the alkalies, earths, and metals—substances of which the crust of the globe is chiefly, if not entirely composed. This distinguished philosopher has shown, that the base of these substances is highly inflammable; and its attraction for oxygen so strong, that it will abstract it even from water; giving rise, at the same time, to a sufficient extrication of light and heat to constitute a genuine case of combustion.[4]

[4] According to Dr. Daubeny, "The theories, which have been propounded, with the view of accounting for the existence of volcanic

We will now consider the first of these theories—that which assumes the existence of a mass of incandescent matter in the centre of the earth. Independently of the reasons already given, this theory rests also for its support on the actual form of the earth—the spheroidal form—being that which a fluid body would assume if revolving in space. As, also, the mean density of the earth is much greater than distilled water—in the proportion of 5·44 to 1·1—and as there are proofs of the presence of melted matter beneath the surface, an additional reason appeared to be afforded why this fluid should have been igneous rather than aqueous. But Sir J. F. Herschel has shown, that the oblate figure of the globe may only have arisen from its long-continued rotation; this being the point to which, under this condition, it must tend, and which it would ultimately attain, even as its surface is at present constituted.[5] Professor Playfair also contends, that if the surface of the earth has repeatedly changed from sea to land, the figure of this our planet would ultimately coincide with its actual one.[6] Lyell again states, that Laplace has shown, by reference to astronomical observations made in the time of Hipparchus, that, in the last two thousand years at least, there has been no sensible contraction of the crust of the globe by cooling; for had this been the

action, may be divided into two classes; those which assume some chemical process, of which the heat is merely an effect, and those which, assuming the existence of the heat, deduce the other phenomena from its presence." *A Description of Active and Extinct Volcanos*, p. 594.

[5] *Treatise on Astronomy.*

[6] *Illustrations of the Huttonian Theory*, p. 435.

case, even to an extremely small amount, the day would have been shortened, whereas its length has certainly not diminished during that period by $\frac{1}{300}$ of a second."[7]

Another reason has been adduced in support of the "nebular hypothesis." This is the fact, that there is a gradual and sensible increase of temperature of the crust of the globe from the surface downwards, at least to those depths to which we have hitherto penetrated. Such proof cannot be of much value, considering how insignificant these depths are. The coal measures only extend five or six thousand feet below the surface, and the Devonian Basin to about twice as much. If we combine these depths beneath the surface with the highest mountain summits, we shall obtain nearly 48,000 feet—a measure equal to about $\frac{1}{524}$ part of the earth's crust. "All that is situated at a greater depth, is as unknown to us as the interior of the other planets of our solar system."[8] As such, it would seem to be somewhat doubtful whether this internal heat is derived from within or from without. The latter is the opinion of Poisson. "This hypothesis, imagined," as Humboldt observes, "by one of the profoundest mathematicians of our time, has not been received by physicists and geologists." And yet there are certain facts that would seem to confirm the conclusion. According to the calculations of M. Cordier and Professor Bischof, we should, on the supposition of a gradually increasing heat from the surface to the centre, and taking the increase we have hitherto obtained—about 1° Fah. in every 51 feet—as our guide, arrive at the melting-point of iron at a depth

[7] *Principles of Geology*, vol. ii., p. 202.

[8] *Cosmos*, p. 150.

not exceeding 24 miles. This, therefore, ought to be the termination of the solid crust of the earth, for such a temperature would be sufficient to fuse all the rocks composing the superficial crust of this our earth. But Dr. Daubeny and other writers have concluded, as the result of certain experiments and observations—some of which will be explained hereafter—that the solid crust of the globe extends to a depth of 800 miles—a conclusion that is fatal to the hypothesis of a central reservoir of melted matter. Then, again, if the increased temperature of the crust of the earth depended on internal heat, we should expect to find the same phenomenon with the waters of the ocean; but this is not the fact. It results from the observations of Kotzebue, Beechey, and Sir J. C. Ross, as a general fact, ascertained by thermometric soundings, that the deep sea water, *below a certain level*, determined by the latitude, is of *invariable* temperature throughout the globe, and *that a very low one*—the calculations of Linz, founded on Kotzebue's results, giving 36° F., and those of Ross 39·5° (which latter is the temperature at which pure water attains its maximum of density). The depth at which the fixed temperature is attained is about 7200 feet at the equator, diminishing on either side of that line to Lat. 56°, where it attains the surface, and the sea (superficial currents apart) is of equal temperature *at all depths*. Thence, again, the upper surface of this uniform substratum descends, and at 90° of latitude has already attained a depth of 4500 feet.[9] Sir Wyville Thompson stated, at the meeting of the British Association, September 12th, 1876, that the following was the result of the experiments made on

[9] *Meteorology*, by Sir J. C. Herschell, p. 40.

board the *Challenger* during her scientific voyage. Over the whole *bottom* of the Pacific and the Atlantic, and those portions of the Southern Sea which they had examined, the temperature was usually a little over the freezing-point. Down in the valleys, it sunk to pretty near the freezing-point; in a few places a little below it. On the elevations, the temperature was somewhat higher. In the Atlantic, they found that from about 500 fathoms to the bottom, the temperature steadily decreased till it came down to the freezing-point, whatever might be the temperature of the atmosphere above, or whatever might be the latitude.[1] It thus appears, that the temperature of the sea at the equator, at a depth of 7200 feet, is not more than from 36° to 39° F.—a decrease instead of an increase as we descend—the contrary to what is observed on land. But there would seem to be no reason why the same law should not hold good in the one case as in the other, if the temperature of the lower strata of the crust of the earth depended on a central fire. Some difference might arise from the greater readiness with which the heat would be diffused in the ocean, as, also, by the mixing of the equatorial and the polar currents; but this effect would be trifling at the equator. As such, the temperature of the ocean in this region, at 7200 feet, instead of being 36° F., ought to be, taking that of the earth as our guide, 141° F. This is without reckoning the influence of the upper stratum of air, heated to 70° or 80° F. Then, again, although the effect of the polar currents would be greater in temperate latitudes, or in Lat. 50°, still, a gradual increase of temperature

[1] The *Times*, Sept. 14, 1876.

ought to be experienced on descending to the lower depths of the ocean, but none has been found. It is only in the arctic regions that there is any increase of temperature below the surface; while this increase is very trifling, being only six or seven degrees above the freezing-point—the invariable temperature of the ocean when uninfluenced by external causes.[2] Instead of the actual temperature, the ocean, if this hypothesis were true, would be a sea of boiling water, as it would repose, at a depth of four miles, on strata having a temperature of 400° F. The contrary being the fact, we may infer, that the temperature of the ocean—local and accidental circumstances apart, as the presence of the Gulf Stream—is dependent on the temperature of the air above. No proof, therefore, can be obtained of the existence of a central reservoir of melted matter from this phenomenon—the gradually increasing temperature of the crust of the globe—any more than from the preceding hypothesis; and no other arguments, worthy of consideration, have been adduced in support of the conclusion.

On the other hand, there are many facts, which would appear to negative the idea of a central reservoir of fluid, incandescent matter. One is, that the density of the earth is greater at the centre than at the surface. The most recent experiments with the balance of torsion are those of Reich, and give, for their result,

[2] Peron concludes, from his own observations, as well as from those of Irvine and Forster, that the deepest abysses of the sea, like the summits of our mountains, are covered with perpetual ice, even under the equator. *Journ. de Phys.* t. 52, p. 361; and *Ann. du Mus. d'Hist. Nat.* t. 5, p. 123.

5·44 to 1, as the ratio of the mean density of the earth to that of distilled water. But the density of the rocks and strata, that form the superficial crust of the globe, is, it has been calculated, not more than 2·7, or, if we take that of the land and the sea combined, 1·6. It follows, therefore, that, either from pressure, or from the heterogeneous nature of the substances, which compose the interior of the globe, there is a great increase of density from the surface to the centre. In order to show, that this density does not arise from the presence of solid strata, and in order to support the "nebular hypothesis," it has been computed at what depths liquid, and even gaseous substances might, from mere pressure, attain a density equal to that of platinum or of iridium; and, in order, as Humboldt has remarked, to bring the actual degree of ellipticity of the earth into harmony with the hypothesis of the infinite compressibility of matter, Leslie conceived the interior of the earth to be a hollow sphere, filled with "an imponderable fluid of enormous expansive force." If, however, such were the case, and if the interior of the globe be a mass of incandescent matter, lava would never cease to flow, after a vent had been once formed, until the external and internal pressure were alike. As, also, we have proof, that vents have existed, on the surface, for thousands of years, the density of the centre of the earth ought, on this hypothesis, to be much less than that of the surface at the present time. The contrary being the fact, we may conclude, that the interior of the earth is not a hollow sphere, but is filled with solid matter. This is Lyell's opinion, who observes: "Experiments made with the pendulum, and observations on the

manner in which the earth attracts the moon, have shown that our planet is not an empty sphere, but, on the contrary, that its interior, whether solid or fluid, has a higher specific gravity than the exterior." (*Loc. cit.*) Whether this matter was originally in an incandescent state, or not, is immaterial at the present moment; all we have to do now is, to ascertain whether the lava, thrown out from time to time on the surface, comes from a central reservoir. That it does not, may be shown by a number of facts. It may be remarked, in the first place, that it would seem to be hardly probable, if possible, for melted matter to be ejected from a central reservoir through the solid crust of the earth—800 miles in thickness—without destroying—at least, in the first instance, and before a vent had been formed—whole continents. So far from this being the case, the eruptions of volcanos are usually attended with less violent and general effects than when earthquakes occur, and when lava is not thrown out. Another circumstance is no less conclusive. It is generally allowed, that the expulsion of lava from the interior to the exterior is due to the expansive force of steam—produced by the precipitation of water on the melted matter contained in volcanic foci. This conclusion appears to be confirmed by the well known fact, that all volcanos are found near to the sea, or great inland collections of water. It is also to be borne in mind, that the fissure, or volcanic vent, is generally formed in secondary strata, composed of rocks, which, by their solidity and texture, may be supposed to offer a great and effectual resistance to the escape of pent-up aqueous or other elastic matter. Hence we may conclude, that the formation of a volcanic vent is due to

the accidental and sudden contact of water on an intensely heated surface, and the consequent generation of a large quantity of steam, which, unable to find an outlet, rends asunder, by its expansive power, the superincumbent strata; ejecting, at the same time, not only the pent-up gaseous matter, but a portion, also, of the melted lava. If, however, there be a gradual increase of temperature from the surface to the interior, as must be the case if the "nebular hypothesis" be true; and if the crust of the globe be 800 miles in thickness; how is the water, we might ask, to penetrate to the central reservoir? If iron would be fused at a depth of only twenty-four miles, water would, as Gay-Lussac has remarked, be converted into steam, long before reaching the strata which are at a white heat. As such, it could not, according to this theory, be the moving power. The strata, also, in the craters of elevation of volcanos, do not, as pointed out by Daubeny, indicate, by the angle they form, that the lava comes from a great depth. Again, if the matter, which issues from volcanos in different parts of the world, came from a central reservoir, or common *focus*, we should expect, that the vents, in this case, would be scattered irregularly over the surface; at the same time that they held, while in a state of activity, a general and common relation to each other. Such, however, is not the case; for volcanos are invariably grouped together in particular regions of the earth's surface, occurring, as Von Buch has already remarked, either scattered along particular lines of the earth's surface, or, else, united in clusters around some common centre—hence the division into linear and central volcanos. It may also be stated, as a fact, that the volcanos in one region, line, or cluster,

hold no relation with those in another and distant part of the earth—while it is as clearly ascertained, that the vents in one particular line or cluster communicate freely with each other. It would therefore appear, that the lava thrown out from volcanic vents, instead of being confined to one common and central focus, is derived from *various and separate reservoirs*—a supposition in accordance with all the facts presented to our notice on these occasions.

There is another circumstance which requires consideration. Although it might be possible, supposing the "nebular hypothesis" to be true, to account for the ejection of melted matter from the interior to the exterior, at certain points of the earth's surface, it will never explain, why the phenomena, attendant on the eruption of the volcano, should vary so much at different times, or, according to the date of its formation. Thus, when a volcanic vent has been formed, the matter ejected at first is almost entirely aëriform, consisting of smoke, aqueous vapour, and gases of different kinds: this is followed at a longer or shorter interval—in some cases not for centuries—by the discharge of melted matter which, together with the products just named, or a part only, continues to be thrown out, at irregular intervals, for a period that varies under different circumstances. After a time, solid matter is no longer ejected, but gaseous substances alone; until, at a still longer period, these products, also, cease to be given out. These different circumstances have occasioned volcanos to be divided into active and extinct, modern and ancient; according as they are in a state of activity or inactivity, and according, also, as their formation

happened during or before historical periods. For instance, in the first eruption of Vesuvius, A.D. 79—no record of such an event having occurred previously—smoke, or gaseous matter, aqueous vapour and ashes, were alone given out. It was during this eruption, that Pompeii and Herculaneum were buried under the ashes or, rather, mud, then ejected. Between this date and 1036, there were five more eruptions, but no lava was thrown out until the seventh. Since then, lava has been ejected at each eruption, and the volcano may be said to be in a state of full activity; the eruptions being frequent and severe. When, however, we turn to the most ancient of the active volcanos, those of the Andes, before described, we find, that there is scarcely an eruption once in a century; and that, when it does occur, ashes, water, and mud, are alone discharged. We may therefore assume, that the time is not far distant—geologically speaking—when these volcanos will become extinct. In other regions, again, where extinct volcanos are alone found, the only evidence we have of the previous existence of volcanic action, is the presence of thermal springs: while even this proof is wanting in other localities. In this case, the existence of volcanic rocks, and the crater-like form of some hill, will be the only indications, that volcanic action occurred in that particular spot, at some remote period,—ages, perhaps, before the formation of man. Now if each vent, on the surface, communicated with one central reservoir, containing incandescent matter, there can be no reason why the products should vary so much in different regions, consisting of aëriform matter in one, and melted lava in another. Besides, this gradual increase and diminution

in the state of activity of a volcano, and this variation in the products at different periods, as well as the total inactivity of the volcano after a certain interval, would seem to show, that volcanic action is local not general; and that it exists only for definite not indefinite periods. The action, in fact, is similar to that of combustion on the surface; or, to the melting of iron in a furnace, excepting as regards its duration.

These circumstances would seem to favour the next of the theories referred to; for they lead to the conclusion that the action which gives rise to volcanic effects is simply one of combustion. Hence Werner, the author of the Neptunian theory, considered that volcanic action was due to the combustion of beds of inflammable matter. But, then, we are unable to understand, how the common process of combustion can take place, or be kept up, in closed reservoirs without the presence of oxygen. We are, it is true, totally unacquainted with the mechanism of the globe; or the means of communication which may exist, between the interior and the exterior, so as to afford the necessary supply of oxygen, in order to keep up the combustion; while it has been inferred, that combustion might occur without the presence of oxygen. Lemery showed, that a mixture of sulphur and iron, sunk in the ground, and moistened, produced combustion: sulphurous vapours being extricated, and even flames. And Breislac concluded, that petroleum was the substance: the combustion being produced by certain combinations of phosphorus or of sulphur. But as the products of combustion, to quote the expression of Mr. Brande, always have reference to the combustible, the substances,

given out from the vents of volcanos, cannot be referred to the combustion of either sulphur, petroleum, or other combustible matter existing on the surface. Besides, the accidental combustion of these substances, at short distances beneath the surface, and within the observation of man, gives rise, as the opponents of this doctrine have remarked, to a train of effects altogether different from those of volcanos; as we have proof of in the accidental burning of coal-mines in many parts of Great Britain; in the combustion of masses of petroleum, as at Baku; and of sulphur or bituminous matter at Macabila.

We are thus forced by the apparent failure of the other hypotheses, and by a sort of *reductio ad absurdum*, to regard the last of these theories, in order to see, if that will account for the production of all the phenomena, known to depend on volcanic action. Although we are unacquainted with the metallic bases, on the surface of the globe, in their pure or primitive state, it has been argued by those who adopt this theory, that there must have been a time, when these substances existed uncombined with any oxygen. It is therefore fair to infer, that the process of oxygenation may still be incomplete in certain situations, and at those vast depths to which air and water have not yet been admitted. If this be granted, all that seems necessary, in order to produce combustion, or inflammation, in these beds, or veins, of pure metals, is the sudden or accidental contact of atmospheric air or water. Now those acquainted with the daily and constant changes going on not only on the surface, but, also, in the crust and interior of the globe, will not be surprised, if both atmospheric air and water should penetrate, from time to time, to situations and

depths, where neither the one nor the other had found access before. There seems, therefore, no *à priori* absurdity in imagining, as one writer has remarked,[3] that volcanic action may consist in a process of oxygenation, caused, in part at least, by the presence of the metallic bases, and their combustion, or union, with oxygen: while, also, we may add, it will explain nearly all the facts connected with the origin and continuance of volcanic action, at the same time that it accounts for those anomalies which belong to the other theories. Nevertheless, many objections have been made to this chemical theory, so many, in fact, that it is entertained by few in the present day—the majority of geologists having adopted the "nebular hypothesis," to the rejection of all others. As one writer has remarked: "It is certainly true that, if this theory (the nebular hypothesis) be not adopted, there is no central idea in the science, nothing about which it can crystallize: and that the whole assemblage of facts, so laboriously collected in physical geology, is without anything to compact it into one harmonious whole."[4] Still, we ought not to retain a false theory, merely because we are unable to account for the phenomena by any other. Nor ought we to reject a theory, merely because it is in opposition to our preconceived opinions, or because, as Dr. Daubeny quaintly observes, it smells of the laboratory. "The majority, indeed, it is conceived, of those who make the subject of volcanos their study," adds the above writer, "have allowed themselves to be biassed by the authority of certain great names amongst

[3] *Encyclopædia Metropolitana*, Art. Geology.

[4] *North American Review*, April, 1869.

mathematicians—of men, who, chiefly anxious to connect the leading facts with those grand conclusions to which their own speculations have conducted them, regarding the internal heat of the planets, concern themselves but little with any minor details, as bearing upon a science in which they take but little interest."[5] (*Loc. cit.*, p. 594.).

One of the objections raised to the conjecture of Davy, is the difference between the specific gravity of the earth and of the metals, in their pure state. The mean density of the earth, as already mentioned, is 5·44: but the specific gravity of potassium is only 0·86; of sodium, 0·97; and of the metals of the earth, 1·2. This difference is considered to be fatal to the theory; but this can only be so on the supposition, that the whole interior of the earth is composed of pure metals. If, however, we infer, that the metals occupy only a portion of the earth's crust, the previous objection falls to the ground. It will be of little importance, what the specific gravity of the combustible matter may be, if it be only contained in separate beds of limited extent—in veins, as it were, the state in which we generally find them. The above objection, therefore, is not a valid one.

Another objection, raised by Professor Bischof, is the supposition, that "no possible amount of chemical action could engender so much heat as is here assumed."[6] But the amount of heat would necessarily depend on the quantity of combustible matter present, and on the quantity of other matter, that became melted by the substance in

[5] *A Description of Active and Extinct Volcanos*, &c, 1848, p. 594.
[6] *The Edin. New Phil. Journ.*, vol. xx., p. 373.

ignition; as, also, the time during which the process was in operation. If the combustible materials existed in large quantities, and if the chemical action were kept up for a long period, as might be the case in closed reservoirs, the proportion of melted matter would necessarily be the same; in which case it might retain its intense heat for centuries. "If," as Lyell remarks, "lava currents of moderate thickness require many years to cool down, in the open air, we must conclude, that the great reservoirs of melted matter, at vast depths in the nether regions, preserve their high temperature and fluidity for thousands of years." These conclusions appear to be confirmed by certain facts, observed on the surface, and cognizable to the senses. Not only do we meet with beds of inflammable matter near the surface; but, when they become ignited, they continue burning for long periods. The old Basset Pit, at Parkgate, near Sheffield, has been on fire for a century, and is still burning. Springs and lakes of petroleum, as, for instance, that at Trinidad, have preserved their heat and fluidity from time immemorial. This objection therefore, like the former, is insufficient to invalidate the chemical theory. Lastly, Bischof remarks, if the lava were formed by the union of the metallic bases with the oxygen of the water, the quantity of *pure* hydrogen, emitted by volcanos, would be immense—a result that is not observed. But Gay-Lussac, assuming that water supplied the oxygen in volcanos, endeavoured to account for the absence of uncombined hydrogen, among the emanations from volcanos, by supposing it to form such combinations with other bodies as would not inflame, when coming into contact with the air. This is the case, when it combines with chlorine to form muriatic acid gas—

a substance that escapes in large quantities from the ducts of volcanos, as well as sulphuretted hydrogen.[7] This explanation does not satisfy Bischof, who considers, that there is not chlorine enough evolved to unite with so enormous a quantity of hydrogen: an objection that would not, perhaps, have been raised, had it not been assumed, that the gaseous products evolved from the ducts of volcanos are the same as those produced at the commencement of the process. This is an error. It is apparent, that the action which produces the melted matter, must have existed for a long period—centuries perhaps—before the formation of the volcano, and previously to any eruption. To assume, therefore, that no free hydrogen is evolved at the commencement of the process, merely because it is not found in abundance at a later period, is alike unphilosophical and absurd. No valid objections, therefore, would appear to have been offered against this chemical theory. It matters not, however, as regards the present inquiry, whether these objections be valid or invalid, or whether what is known by the term volcanic action, be the process conjectured by Davy or any other. It is sufficient, for the present argument, to conclude, that it is a particular process, which exists for definite, not indefinite periods; and that the melted matter is contained in superficial and separate reservoirs, not in a single or central one. This conclusion is strengthened and confirmed by the researches, made since the first edition of this work was published, of a profound mathematician.[8]

[7] *Annales de Chimie et de Physique.* t. 37, p. 133.

[8] Some of these observations and experiments, or, rather mathematical calculations, were published previously to the publication of my work, in 1841, but they were not completed until

Mr. Hopkins, assuming that nothing is, as yet, known on the subject, enunciated the following propositions. (1) The earth may consist of a solid exterior shell, and an internal mass, in a state of fusion. (2) It may consist of an exterior shell, and a central solid nucleus, with matter in a state of fusion between them. (3) The earth may be solid from the surface to the centre. In order to solve these problems, Mr. Hopkins considered, that "a test might possibly be found in the delicate, but well-defined, phenomena of precession and nutation.[9] As the precession of the equinoctial points, arising from the nutation, or oscillation of the earth's axis, is due to the attraction of the sun and moon, and principally the moon, on the protuberant matter at the earth's equator, it follows, if these parts were solid to a great depth, the motion thus produced would differ considerably from that which would exist, if they were perfectly fluid, and incrusted all over with a thin shell only, a few miles thick." It is not

the following year: while I was unacquainted with them until long after. A few years previously to this, or to the publication of my work, a paper was inserted by me, in the *Boletin de Medicina, Cirujia y Farmacia*, No. 64, August 20th, 1835, during my stay in Madrid, in which the proposition was laid down, that epidemic diseases are produced by volcanic action, and for the following reasons:—1st. Que tanto la accion volcánica come las enfermedades epidémicas estan ambas sujetas à leyes, ó idénticas, ó muy parecidas. 2nd. Que estos duos efectos de una misma causa, aunque opuestos ó por le menos distintos, son siempre mas ó menos los compañeros el uno del otro."

[9] In astronomy, the precession of the equinoxes is a slow, but continual shifting of the equinoctial points from east to west. The amount of precession, annually, is about 50 seconds. Hence, the equinoctial points will make an entire revolution in 25 years. Nutation is a vibratory motion of the earth's axis, arising from periodical fluctuations in the obliquity of the ecliptic.

necessary to enter into any detail of the elaborate calculations and experiments made by Mr. Hopkins: those interested in the subject can refer to the original papers, entitled *Researches in Physical Geology,* and inserted in successive numbers of the *Philosophical Transactions,* from 1839 to 1842. It will be sufficient, on the present occasion, to give the result at which the writer has arrived.

Mr. Hopkins remarks: "Upon the whole, therefore, we may venture to assert, that the minimum thickness of the crust of the globe, which can be deemed consistent with the observed amount of precession, cannot be less than one-fourth or one-fifth of the earth's radius—or from 1000 to 800 miles." If, however, the crust of the earth, as thus shown, be of this thickness, the propulsion of melted matter from a central reservoir, would be as previously remarked, scarcely possible in the present condition of this our globe. This is Mr. Hopkins' opinion, who remarks: "Many speculations, respecting active volcanos, have rested on the hypothesis of a direct communication, by means of the volcanic vent, between the surface and the fluid nucleus beneath; assuming the fluidity to commence at a depth little, if at all, greater than that at which the temperature may be fairly presumed to be such as would suffice, under merely the atmospheric pressure, to fuse the matter of the earth's crust. When it is proved, however, that the crust must be several hundred miles in thickness, the hypothesis of this direct communication is placed, as I conceive, much too far beyond the bounds of all rational probability to be for an instant admitted, as the basis of theoretical speculation. We are necessarily led, therefore, to the conclusion, that the fluid matter of actual volcanos exists

in subterranean reservoirs of limited extent, forming subterranean *lakes*, and not a subterranean ocean." And it is then added: "Such, also, we conclude, from the present thickness of the earth's crust, must have been the case for enormous periods of time; and, consequently, that there is a very high degree of probability, that the same was true at the epochs of all the great elevations which we recognize, with the exception, perhaps, of the earliest. If, moreover, we find, that the hypothesis of these subterranean lakes, at no great distance beneath the surface, does enable us to account distinctly, by calculations founded on mechanical principles, for the phenomena of elevation, and the laws which they follow, then have we all the proof of the truth of our hypothesis, which the nature of the case will admit.[1][2] Sir Charles Lyell has arrived at a somewhat similar conclusion, not from mathematical calculations, but from simple deduction. He remarks: "That lakes of lava are continuous for hundreds of miles beneath the Chilian Andes, seems established by observations made in the year 1835. According to Mr. Caldcleugh and Mr. Darwin, the whole volcanic chain of

[1] *Phil. Trans.* 1842, p. 42.

[2] M. Delaunay, the eminent astronomer, has brought forward some objections to the arguments advanced by Mr. Hopkins; but Sir W. Thomson, after a careful consideration of them, states, that the hypothesis of a viscous fluid, assumed by M. Delaunay, can be mathematically proved to be insufficient for the phenomena, which cannot, he believes, be accounted for, unless the crust of the earth have a thickness of, at least, 2000 or 2500 miles, and a rigidity approaching that of a globe of solid glass.—*Comptes Rendus*, July 13, 1868, and *Nature*, Jan. 18, 1872, p. 233, and Feb. 1, p. 257.

the Chilian Andes, a range 1300 miles in length, was in a state of unusual activity, both during the shocks, and for some time preceding and after the convulsion, and lava was seen to flow from the crater of Osorno. In November of the same year, Conception was shaken by a severe earthquake, and, on the same day, Osorno, at the distance of 400 miles, renewed its activity."

This conclusion—that of a *lake* of melted matter—although highly important, is insufficient in my opinion, to explain all the effects resulting from volcanic action: the majority of these effects being observed along extended and well-connected lines of the earth's surface, as must be evident from what has gone before. I should therefore conclude, that the melted matter forms, not lakes but subterranean rivers, extending over large portions of the terrestrial sphere—a distance, in many cases, as great as from the pole to the equator, or from one pole to the other.

If there be a subterranean river, there must also be a subterranean cavity, or tunnel, beneath the surface, extending the same distance. That such is the case, we may conclude, not only from what has gone before, but, also, from the phenomena witnessed during the occurrence of earthquakes. It is generally supposed, that the earthquake, like the eruption of the volcano, is produced, as previously stated, by the expansive force of steam, due to the accidental contact of water on the melted matter. Other geologists conclude, that it is caused by the condensation and sudden expansion of elastic vapours in pent-up reservoirs. Be this as it may, it is considered, by the majority of geologists, that the shock of the earthquake is derived from a common focus, and thence

propagated through the strata in particular directions. Mr. Mallett, who has paid particular attention to the phenomena of earthquakes, and who has attempted to reduce the study of them to something like a science—the science of Seismology—infers, that the shock, or earth-wave, is a true undulation of the solid crust of the earth: or, as he expresses it, in another place, "the transit through the earth's crust of a wave of elastic compression."[3] [4] Were this the case, the effects resulting from earthquakes ought to be felt, principally, in a circular direction, and vertically rather than horizontally. But Humboldt states, that the circular, or gyratory, earthquake is the most rare: the vertical less so, and the horizontal, or linear the most common. "The shocks," adds the Baron, "are propagated chiefly in a linear direction, by undulations having a velocity of from 20 to 28 geographical miles a minute."[5] Mr. Mallett also states, that "the motion of translation of the earth-wave, or shock, is rectilinear, not curvilinear." Why this should be, it seems difficult to understand, on the hypothesis of the shock being propagated from a central focus of limited extent, and from a vertical shaft; more particularly when we find that the lines, in each volcanic district, are invariably the same, at each concussion; and that, although extending over considerable

[3] These conclusions of Mr. Mallett are of course based on the "nebular hypothesis"—on the supposition, that the melted matter is propelled from a central reservoir to the surface, through a duct; and that the point of departure of the concussions is from this duct, or subterranean chimney.

[4] On the facts of earthquake phenomena. *Report of the British Association*, 1850, vol ii., p. 273.

[5] *Cosmos*, p. 192.

portions of the globe, their lateral boundaries are very limited. Then, again, concussions occur, along the whole of this extended line, passing gradually from point to point, at particular intervals, and being limited, for the time, to these particular spots. At other times, instead of progressing regularly along the line, a concussion will be felt at one point only; at another time, at another point, the shocks being confined to an area of limited extent. How, then, are we to account for these phenomena, by the ordinary hypothesis? Are there vertical shafts beneath the surface, and scattered along the whole of these lines? That is not probable, more especially when no volcano exists, as is sometimes the case, along the whole line; or, when, if there be any, they are only to be found at one or two points of a line, extending from Asia to the continent of America. These are anomalies that cannot be explained, on the supposition of the shocks being propagated through the solid strata from a central area of limited extent, and by the escape of steam through a vertical shaft. Were this the case, we should expect to find, that earthquakes were more violent in the immediate neighbourhood of the volcano than elsewhere: but this is not the fact. On the contrary, the concussion is usually the severest at a distance from the volcano, and in situations where no volcanic vent exists.

Independently of the shocks, noises are sometimes heard during an eruption or an earthquake, at a spot where no shock is felt, and at long distances from the volcano, or the place where the concussion occurs: and this, too, when no sound is heard in the intermediate places. In 1744, at the eruption of Cotopaxi, subter-

ranean noises, as of cannon, were heard at Honda, near the Magdalena river. Not only is the crater of Cotopaxi about 18,000 feet higher than Honda, but these two points are separated from each other by a distance of 436 miles, and by the colossal mountain masses of Quito, Pasto, and Papayan, as well as by countless valleys and ravines. "The sound," remarks Humboldt, "was clearly not propagated through the air, but through the earth, and at a great depth."[6] (*Loc. cit.*, p. 195.) The great depth is a supposition of the renowned traveller, not confirmed by experience.[7] He also remarks that, in the Caracas, in the grassy plains of Calaboso, and on the banks of the Rio Apure, which falls into the Orinoco, there was heard, over the space of 2300 square (German) miles, a loud noise resembling thunder, unaccompanied by any shaking of the ground: whilst, at a distance of 632 miles to the north-east, the crater of the volcano of St. Vincent, one of the small West India Islands, was pouring forth a prodigious stream of lava.[8][9] How, then, is this phenomenon to be explained? Mr. Mallett, the great authority on this subject, remarks: "The occurrence of sound at all, necessarily infers *impulse* at the focus, of the nature of a blow, or a succession of them;

[6] *Cosmos*, p. 195.

[7] Mr. Mallett calculates that, in the Calabrian earthquake of 1857, the greatest number of the wave-paths started from a *vertical depth*, not exceeding 3 geographical miles or 18,225 feet. The maximum depth he gives at $8\frac{1}{8}$ geographical miles, and the minimum depth at $2\frac{3}{4}$ miles.

[8] It may be as well to remark, that the volcanic line of the West Indies is prolonged westward across the continent of America, and intersects the Chilian line.

[9] *Personal Narrative*, vol. iv., p. 27.

either due to fracture of hard and elastic material; the sudden separation, or rending open further, of existing fissures, or cavities; or, the sudden rush out of highly elastic steam, or its as sudden production, or condensation." (*Loc. cit.*, vol. ii., p. 286.) If the noise, in these instances, be the effect of an impulse on the solid crust of the earth, at such distances, the intermediate places ought also to exhibit the same phenomenon: but this is not always or generally the case. Then again, the noise is not always synchronous with the concussion. It was not until some time after the great earthquake of New Grenada, November 18, 1837, and described by Boussingault, that subterranean detonations, *unaccompanied by any movement,* or shock, were heard, with great regularity, at intervals of 30 seconds, throughout the whole Cauca valley. Humboldt also states, that the great subterranean detonation (*el gran ruido*), which was heard at the cities of Quito and Ibarra, but *not* at Tacunga and Hambato, which were nearer the centre of the movement, occurred 18 or 20 minutes after the catastrophe, or the concussion. It also appears that the noise, which accompanies earthquakes, bears no proportion to the violence of the oscillations. "I have distinctly ascertained," observes Humboldt, "that the great shock of the earthquake of Reobamba (4th of February, 1797)—one of the most terrible phenomena in the physical history of our globe—was unaccompanied by any noise." (*Loc. cit.*, p. 194.)

As the noise and the shock are not invariable accompaniments the one of the other, or synchronous; and as the noise is frequently heard at great distances from the spot where the concussion is felt; while the intermediate

places are unaffected; we may reasonably infer, that the detonations are not produced by an impulse on the solid crust of the earth, at a distance from the spot where they occur. At other times, again, noises are heard without any shock being experienced, either at that spot or elsewhere. The most striking instance of uninterrupted subterranean noise, remarks Humboldt, unaccompanied by any trace of earthquake, or concussion, is the phenomenon which is known in the Mexican territory by the name of *Bramidos y truenos subterraneos* (or, subterranean roaring and thundering) of Guanaxuato,—a rich and celebrated mountain city, situated at a distance from any active volcano. For instance, on the 9th January, 1784, the noise began at midnight, and lasted above a month. From the 13th to the 16th, it was as if there were *heavy storm-clouds under the feet of the inhabitants*, in which slow rolling thunder alternated with short thunder-claps. Neither at the surface, nor in mines, 1598 feet deep, could the slightest trembling of the ground be perceived. (*Loc. cit.*, p. 196.) As, also, these noises are only heard in particular spots, and on certain lines of the earth's surface, it would seem to be impossible to account for their production, except on the supposition, that there are subterranean cavities extending along these lines, for the whole of the distance. Such an inference will enable us to explain, not only some of the anomalies already considered, but, also, why earthquakes are sometimes progressive, commencing at one particular spot, and then extending, slowly and regularly, at certain intervals, along well-defined lines, and over considerable spaces of the terrestrial globe.

The rate at which the shock, the sound, is propa-

gated, also leads to the conclusion, that there is a hollow cavity beneath the surface, in the direction in which these effects are perceived. According to Humboldt, earthquakes travel at the rate of from 20 to 28 miles in a minute: but it is less than this in many instances. Mr. Mallett calculates the velocity of the earth-wave, or shock, at 12,039 feet per second—equivalent to about 13 miles in a minute. Now this is very nearly the rate at which sound is propagated through the air—12½ miles per minute. This circumstance would lead to the conclusion, that both the shock and the sound are propagated, not through the solid strata, but through air, or a medium having about the same density. If so, there must be a subterranean cavity, or tunnel, filled with air or some elastic fluid, through which the sound passes—it being evident that the sound travels beneath, not above the surface. If it were propagated through the solid rocks, as inferred by Mr. Mallett, it would travel more rapidly —3 times more rapidly through lias, 6 times through limestone, and 10 or 12 times more rapidly through hard slate and burnt clay.

With these facts before us, the only inference to draw would appear to be, that the melted lava beneath the surface forms rivers not lakes, and that the reservoirs, in which it is contained, are tunnels of narrow dimensions but of great lengths. This inference receives support from the nature of the sound. In the narrative of the New Zealand earthquake, in 1855, it is remarked: "The noise is like the noise of a railway train, running *through a tunnel*, when a person is standing at the mouth." The character of the concussion also leads to the same conclusion. The motion then produced on the surface of the

earth—a wave-like one—has been compared, by Mitchell, to a carpet, under which air is blown. In the earthquake in Jamaica, in 1692, an eye-witness stated, that the ground heaved and swelled "like a rolling, swelling sea," insomuch that people could hardly stand upon their legs by reason of it. So, also, in the concussion in New England, in 1755, the tops of the trees were observed to vibrate *ten* feet, like the pendulum of a clock. Effects like these could hardly be produced by a shock, or impulse, at a given point, and thence transmitted through the solid strata, without causing a disruption of the earth's crust along the path of the earthquake. If, however, we conclude, that there is a hollow beneath, at no great depth, the difficulty ceases. It is only on this supposition, that we can understand the slight damage that sometimes occurs during severe concussions. This circumstance has not escaped the observation of Mitchell, who remarks: "What must the size of that cavern be, which could contain vapour enough to produce the earthquake of 1759; or how can we suppose, that the roof of such a cavern, when so violently shaken, should avoid falling in." It has been computed, that the earthquake at Lisbon pervaded an area of 700,000 geographical miles: or the twelfth part of the circumference of the globe. If, however, instead of a central reservoir or circumscribed cavity—the lake of Mr. Hopkins—in each volcanic region, we infer, that a narrow and lengthened tunnel exists, extending over considerable spaces of the terrestrial sphere, the elastic vapour generated at such times might rush along this tunnel, without rending asunder the solid crust of the globe; as would inevitably be the case if confined within narrower bounda-

ries. Such a result, it is true, does frequently occur, but the effects are insignificant compared to those that would otherwise be observed.

Having thus attempted to define what is termed volcanic action, and endeavoured to show the manner in which volcanic effects are produced, we may now proceed to consider the way in which epidemic diseases arise—it having been assumed, that they, also, are products of the same cause. As before stated, it is generally allowed, that the eruption of the volcano, and the shock of the earthquake, are produced by the precipitation of water on the melted matter contained in volcanic *foci*. If, however, the ejection of lava, from the interior to the surface, be due entirely to the accidental presence of steam; we must allow that, at other times or in other situations, where the same action is going on, this phenomenon cannot be witnessed, from the absence of those contingent circumstances necessary for its production. These are, the contact of water with the melted matter; its conversion into steam in sufficient quantity to overcome the weight of the superincumbent strata; and its confinement within certain boundaries, so as to be able to exert a hydrostatic pressure sufficient to produce a volcanic vent, and the propulsion of the pent-up matter. Such being the case we cannot be surprised to find, that volcanic eruptions take place so seldom, even in situations where earthquakes are frequent and common; for the power, that is insufficient to rend asunder the crust of the globe, may, nevertheless, be adequate to produce not only slight tremors but even violent concussions. We must also infer, that even this effect, at other times and in other situations, cannot take

place; although the process itself, whatever that may be, which is known by the term volcanic action, is in existence at the time. Thus, if water does not percolate at all to the reservoirs of melted matter, or only in small quantities, no concussion can be felt, if we allow, that earthquakes are produced by the same cause as that which gives rise to the eruption of the volcano—a conclusion, that we are bound to admit in the present day; for we may, as Lyell truly remarks, regard earthquakes as abortive volcanic eruptions. Granting, however, that the shocks sometimes felt on the surface of the earth are produced, not by the expansive power of steam, but, as some geologists would have us believe, by the condensation of other and permanently elastic gases, the product of the volcanic process; still, it is evident, even then, that this phenomenon can only be produced under particular circumstances; for unless gaseous matter be evolved in sufficient quantity, and unless it be confined for a sufficient length of time, to produce the necessary condensation, no concussion would be felt.

But, then, it would be most unphilosophical to suppose, because we have none of those great catastrophes, which proclaim the operation of this cause on the crust of the globe, that the action productive of them is dormant, either during the interval of their occurrence, or in situations where these phenomena are not observed at all. On the contrary, we have proof, that this action does not cease with the subsidence of the above effects; as a variety of circumstances show, that volcanic foci retain their intense heat for ages. We may therefore assume, with a writer in the *Encyclopædia Metropolitana*, "that the eruptions of burning mountains are only the external

manifestations of a cause generally diffused throughout nature; and that the minor indications of the same may therefore be looked for, when these mightier ones are unknown." This is confirmed by numerous phenomena; for, as Lyell states, "perennial supplies of hot vapour and aëriform fluids rise to certain craters, which are in a state of ceaseless eruption. Numerous solfataras, evolving the same gases as volcanos, serve as permanent vents of heat generated in subterranean regions. The plentiful evolution, also, of carbonic acid from springs and fissures, throughout hundreds of square leagues, is another regular source of communication between the interior and the surface. Steam, also, often above the boiling temperature is emitted for ages, without intermission, from 'stufas,' as the Italians call them. Even silex, carbonate of lime, muriate of soda, and many earths, alkalies, and metals, are poured out in a state of solution by springs, and the solid matter, which is thus tranquilly removed in this manner, may, perhaps, exceed that which issues in the shape of lava." In fact, it is probable, as the above author suggests, that we owe the comparative tranquillity of our globe to the efficacy of this ceaseless discharge of heat, and of solid, as well as of gaseous matter. But it is principally in the neighbourhood of extinct volcanos, or in situations where earthquakes have been frequent, and chasms formed, that these phenomena are observed. We have proof, however, of the evolution of gaseous matter from subterranean reservoirs at other times, and in other situations. This effect is most apparent during the eruption of the volcano, particularly on its first formation; as must be familiar to all who have perused the accounts of such visitations. A remarkable

example was afforded by the eruption in the island of St. Vincent, in 1812, which began by an abrupt and dreadful crash from the mountain, called Souffriere; and was proclaimed, in a moment, by a vast column of thick, black, ropy smoke, like that of an immense glass-house. On the following day, it appeared like a compact, pitchy, column, rising perpendicularly from the crater to an immense height. Those who have witnessed an eruption of Vesuvius, must also have remarked the column of vapour rising from the crater during the day, and the glare at night, caused by the ignition of some of the gases then evolved—the flame being invisible in the day-time. Minor effects of the same kind are also observed during the occurrence of earthquakes. But, in addition to the gaseous matter discharged from the craters of volcanos, and the fissures formed by earthquakes, at the time of the eruption of the one and the occurrence of the other, various gases are also given out from the bowels of the earth, *silently and invisibly*, before the above phenomena are observed; although, for obvious reasons, the source, whence the matter is derived, is not so evident in this instance as in the former—its diffusion in the atmosphere being so gradual as to be nearly imperceptible. The phenomenon, however, has been observed to precede eruptions and earthquakes so frequently, and to occur in situations and at times when no other reason can be assigned for its production, that no doubt can possibly exist as to the cause. Thus, for some months previously to the eruption of Hecla, Iceland, in 1783, the atmosphere of the whole island was filled with a dark, bluish sulphurous vapour, or cloud, which was stationary in calm weather, and, at other times, was blown over the

neighbouring countries. So, also, in the memorable earthquake at Lisbon, in 1700, a thick fog was perceived on the morning of the fatal day, both in that city and in other places near; while a remarkable haze, or mist, which obscured the sun's rays, was also visible on the *day preceding* the tremendous concussion, which laid Lisbon in ruins in 1755. Humboldt, referring to the phenomena that occurred during an earthquake at Cumana, says: "On the 18th October, a reddish vapour rose above the horizon, and covered, in a few minutes, as with a veil, the whole azure vault of heaven." From the 28th October to the 3rd November, the mist became denser and denser, and, on the 4th, there were two shocks of an earthquake. So, also, the remarkable fog of the month of May, 1783, described by Fourcray, preceded the earthquake in Calabria *by a month.* In fact, everything in earthquakes, as Humboldt has observed, seems to indicate the action of elastic fluids, seeking an outlet to spread themselves in the atmosphere.

Remarking, therefore, that gaseous matter is thus given out from the bowels of the earth, not only at the time, but antecedent to the eruption and the shock, it is necessary to ascertain how this evolution takes place. If the reservoirs from which these gases are derived exist at a comparatively slight depth beneath the surface, it is easy to conceive, that they may, under certain circumstances, escape through the superincumbent strata,—even when a pressure much less than that, which produces the shock and the eruption, is alone exerted. But it will, in other cases, be impossible to draw such an inference, as the solidity and nature of the superincumbent strata must prevent their escape in this direction; for although earth-

quakes are most frequent on tertiary formations and in alluvial districts, they are not entirely confined to these situations, but are also witnessed on secondary, and, sometimes, on primary formations. As it is clear, that the evolution of gaseous matter from the bowels of the earth, before any fissure or vent has been formed on the surface, could not take place through the interstices of the majority of the rocks composing those formations termed primary and secondary, we must look to some other means for the production of this effect.

In so doing, we are at once led to regard those natural outlets, formed by the streams which penetrate to various depths; and convey to the surface that fluid, so necessary for the health and the life of man. Now these streams, or springs, abound in all situations, being found in the hardest rock as well as in the soft and humid beds of alluvial tracts. They are, however, more abundant in the latter situation than in the former—while they are comparatively rare in primary formations. If springs, therefore, penetrate to volcanic foci, to such channels we may, in all probability, look for the discharge of those gases, which escape from the interior to the exterior, before the formation of any vent or fissure. This inference is strengthened by the fact, that *thermal* springs exist in the neighbourhood of all active volcanos, at the same time that their production can generally be referred to the same epoch as the volcano itself; while, also, it has been found, that the same mineral and gaseous matters are contained in their waters, as those which are given out from volcanic vents. The relation, indeed, as Sir Charles Lyell justly observes, of almost all springs, impregnated copiously with mineral

matter, to the sources of subterranean heat, seems placed beyond all reasonable doubt by modern research. More than this, we find that these springs continue to give out the same substances, and to retain their increased temperature, long after the volcano has become extinct; by which it would appear, that the products of volcanic action escape more readily by these channels than from the ducts of volcanos. As it is evident, that the waters of mineral springs penetrate to volcanic foci, the question of most importance at the present moment is, do the same products, and especially gaseous matter, escape by the same channels, or by ordinary springs, at other times, and in situations in which no sign of volcanic action is in existence? That such is the case, we may infer from numerous phenomena. Thus, previously to the concussion or the eruption, the sea frequently swells up and makes a great noise, at the same time that the waters of the neighbouring springs are observed to become muddy and to overflow—effects which are frequently experienced at considerable distances from the spot, where the concussion occurs. Whether the waves produced in the sea, at the spot where the concussion is felt, be the effect of an alteration in the level of the land, which forms the bottom, or whether it be the effect of some other cause, must be matter of opinion and discussion. But of this there can be no doubt, viz. that gaseous matter escapes in large quantity from the waters of the ocean, not only during eruptions and earthquakes, but, also, *before any shock has been experienced.* Thus, before the earthquake which happened at Oporto in 1755, the river opened, and seemed to discharge an immense quantity of *air.* Again: Previously to the earthquake which occurred in Calabria in

1638, the sea, as we are informed by Kircher, seemed to wear a very unusual appearance: those who have seen a lake in a violent shower of rain, all covered over with bubbles, may, says this writer, have some idea of its agitation. It is also recorded, that the fishermen, at the same time, were obliged to relinquish their occupations, and to land; for though *there was no wind*, yet the sea, for some distance, appeared to be in an extraordinary state of ferment and ebullition. It is remarkable, also, that seamen sometimes observe a swelling of the ocean *without wind*, and before any shock has been experienced; and this fact Pliny mentions among the signs of an approaching earthquake. This phenomenon can only, we may presume, be ascribed to the escape of gaseous matter from the bottom of the sea; and this matter, we may further infer, is derived from the mouths of those springs, which rise up as freely beneath the waters of the ocean, as on the surface of the dry land.

This inference receives support from the fact, that the same agitation in the water has been observed in situations far removed from the centre of th concussion; and when no shock has been perceived, either then or subsequently, in the solid crust of that part of the globe. This was very remarkable at the time of the earthquake at Oporto, just referred to. It was only in Portugal, that any elevation of the superincumbent strata took place: but agitation, or movement, in the waters of the sea, rivers, &c., was observed in France, England, Germany, and even as far as Norway and Sweden. That the waters of the ocean should have been affected in situations, far removed from the centre of the concussion, will not, perhaps, excite surprise, when it

is known, that an immense wave was produced at Oporto, and that ships at sea a considerable distance from the coast also felt the concussion. But, independently of the sudden flow and ebb of the water on the sea-coast in England, Holland, Norway, &c., the same agitation was observed in *inland collections of water*, as ponds, lakes, &c. Thus, at the same time as the concussion in Portugal, and the agitation of the sea in that and other countries, the water in ponds in various parts of England, and in the canals and dikes in Holland, was observed to be agitated, and to have its level altered. At White-rock, Glamorganshire, the water suddenly rose in the river, floated two large vessels, the least of them above 200 tons, broke their moorings, and nearly upset them. This effect, says the writer of the account, *was not felt in any other part of the river;* so that it (the water) seemed to have gushed out at that very place, and no concussion was felt on the dry land for hundreds of leagues from the spot where the phenomenon occurred. At Toplitz in Bohemia, and many other places, the hot springs had their contents rendered turbid; at the same time that large quantities of water rushed out with great violence, on the day that the concussion occurred. We may therefore infer, that this sudden discharge of water from springs is produced by the escape of gaseous matter through these particular channels. That the movement in the water of ponds, springs, &c., in places far removed from the centre of the concussion, and in situations in which no other effect referrible to the same cause has been observed, is thus produced, may be inferred from a phenomenon, stated to have taken place at Amsterdam and other places. This was a sudden vibration and

movement in the chandeliers, and other pendulous articles, in the churches and houses, at the moment when the agitation in the waters was observed, although the atmosphere appeared to be perfectly calm. This effect admits of explanation, by supposing that there was a sudden rush of air from some source; and as the water in the canals and dikes—which, be it remembered, had no communication with the sea, and could not, therefore, be influenced by the immense wave produced in the ocean—were similarly affected, it is fair to infer, that the elastic matter, which gave rise to the phenomenon, was derived from the springs beneath—especially as the effect was too sudden and too great to have been produced by any insensible concussion of the crust of the globe. These inferences are strengthened by another fact, which is, that the same phenomena were actually observed, in some places, before the concussion. Mitchell states, that the agitation in the waters of Lochness, Lochlomond, &c., preceded the earthquake at Lisbon by about *half an hour*. The same result was observed in Switzerland, the agitations in the water of the lakes having, according to M. Bertrand, occurred three quarters of an hour before the earthquake.

Having thus shown, that there is a considerable evolution of gaseous matter from the interior to the exterior, previously to, during, and subsequently to, the eruption of the volcano, and the shock of the earthquake, it only remains to ascertain, whether any of the gases thus extricated be of a poisonous nature. That such is the case admits of no doubt, as extensive disease and mortality frequently occur after volcanic eruptions and concussions, among the inhabitants of the surrounding

districts. Although the population of Iceland did not then exceed 50,000, more than 9000 human beings, and an immense number of cattle, perished during one eruption only of Hecla. This loss is to be referred, partly, to the depredations of the lava, and, partly, to famine; but, principally, to the noxious vapours which impregnated the air. So, also the consequence of the earthquake in Jamaica, in 1690, was, we are told, a general sickness—3000 persons of those who survived the effects of the shock being swept away by pestilence. In the Calabrian earthquake, A.D. 1783, upwards of 40,000 persons, according to Sir William Hamilton, were killed; and 20,000, he calculated, died of disease subsequently. Again: In the eruptions in Italy in 1329, every species of animals and birds perished in great numbers; and Seneca relates, that a vapour, caused by an earthquake in Campania, destroyed 6000 sheep. But deleterious substances are not only given out from the vents of volcanos, and the fissures formed by earthquakes; they also escape from the mouth of those springs, that discharge their contents beneath and into the waters of the sea, as is shown by their effect on the finny race. Thus in the eruption, which took place in the island of Lancerota, in 1730, dead fish floated on the waters in indescribable numbers, or were thrown dying on the shore. In June, 1731, also, during a renewal of the eruptions, all the banks and shores, in the western part of the island, were covered with dying fish of different species; some of which had never been seen before.

The preceding are not the only channels, by which gaseous matters escape into the surrounding atmosphere

from volcanic foci; they are also given out from the surface, or from particular soils on the surface. Humboldt states, that in the Savannahs of New Andalusia—a volcanic region—flakes of fire rise to a considerable height: they are seen for hours together in the driest places; and it is asserted that, on examining the ground which furnished the inflammable matter, no crevice is to be found. Hence the source of the deleterious emanations, that are found to exist in certain situations; not occasionally only but continuously. About midway between Vesuvius and Mount Vultur is the *Lago di Ansanto* (the ancient *Amsanctus*), celebrated for the mephitic gases which it exhales. The quantity of gaseous matter that escapes from one spot of a small rivulet, which flows from the lake, is so great, that Dr. Daubeny, in his visit to that part of Italy, was obliged to make a détour to avoid it. This is the origin of the fable of the *Vado Mortale*, according to which the rivulet cannot be forded without death; and where the whitened bones of the animals, that had perished there, remain without any one being able to approach near to remove them. Formerly, there was a wood situated between this lake and the town of Villa Maina, four miles distant, but, since this was cut down, the inhabitants have suffered materially in their health, and particularly from affections of the liver. Dr. Daubeny also states, that, "in the island of Milo, as well as in the Phlegrœan fields near Naples, noxious miasmata so abound, that the few inhabitants of this once populous island are the very pictures of wretchedness and disease." [1]

[1] Near to Mount Vultur,—an extinct volcano, in the kingdom of Naples,—are the remains of a temple, that was dedicated to the god-

Observing that gaseous matter is given out thus freely from volcanic *foci,* and in situations where no vent or chasm exists, it is probably, to this source that we must look for the origin of those extensive mists, or fogs, that so frequently occur, but the cause of which has hitherto been regarded as inexplicable. We shall be strengthened in this conclusion, when we find that these fogs have been observed more particularly at epidemic periods, and in well-known volcanic regions; although, as might be inferred, they also prevail in situations in which no evidence exists of volcanic action. Thus, the plague of Egypt, in Pharaoh's time, was attended by darkness; as was that in Rome, A.D. 252 and 746. In the plague which desolated Rome, B.C. 296, there was also a remarkable darkness, under favour of which the Samnites attacked the Roman lines. We also hear of the same phenomenon during the prevalence of the black death of the 14th century; for the majority of writers speak of the thick, stinking fog, which accompanied the march of this plague:—"A dense and awful fog," says one writer, "was seen in the heavens, rising in the east, and descending upon Italy."[2] Hence Hodges, in his treatise on the great plague in London, 1665, concluded, that it was produced by a subtle *aura,* or vapour, extricated from the bowels of the earth. Similar results have been seen and noted during the prevalence of murrains. Thus, thick mists (of a bluish colour) were observed to precede the diffusion of the memorable murrain described by

dess Mephitis; and Romanelli mentions an inscription, found on the road near, of a votive offering, presented to the goddess by a Roman lady—thus: *Paccia Quintilla Mifeti votum solvit.*

[2] *Mansfield Chronicle.*

Dr. Winklan; a malady which broke out in Italy,[3] and spread through Switzerland, Germany, Poland, and Holland, until at last it reached England. The fatal angina maligna among cattle, in 1632, was also attended with a blue mist, or dew, on the herbage or pastures.

The same phenomenon has been observed during the prevalence of epidemic cholera, fogs and mists having been its accompaniment both in the East and West, while they have prevailed to so great an extent as to attract general attention. The first account we have of the phenomenon comes from China, and is contained in the work of M. Hue, a Jesuit missionary. He remarks: —"In the first year of the reign of the deceased Emperor [it must be remembered that one has died since this was written]—that is to say, in the year 1820—a mass of reddish vapour was noticed one day upon the surface of the Yellow Sea. This singular phenomenon was observed by the Chinese of the province of Chang-tong, which forms its coast. The vapour was at first light, but gradually increased, became condensed, rose little by little above the surface of the water, and at last formed an immense red cloud, which remained for several hours floating in the air. The Chinese were seized with terror, as they mostly are in the presence of all great natural phenomena, and sought in certain superstitious practices of the Bonzes the means of averting the threatened calamity. . . . Whilst the inhabitants of Chang-tong were seeking to conjure away this unknown misfortune, which yet every one foresaw, a violent wind suddenly began to blow, and, dividing the cloud into various

[3] *Phil. Trans.*, vol. xiii., p. 93, A.D. 1683.

columns, drove them on toward the land. These red vapours spread in a winding course along the hills and valleys, and swept over the towns and villages; and, wherever they passed, men found themselves suddenly attacked by a frightful disease, which, in a moment, deranged the entire organization, and changed a living man into a hideous corpse. In vain did the doctors anxiously turn over their books; nowhere could they find any hint of this new, strange, and terrible enemy, that struck like a thunderbolt, sometimes on one side, sometimes on the other—on poor and rich, young and old—but always apparently in the most capricious manner, without following any fixed rule in the midst of its fearful ravages. Numberless remedies were tried, numberless experiments made, but entirely without success, and the implacable scourge went raging on with unabated fury, plunging whole populations into terror and mourning.

"According to all that the Chinese have told us of this terrible malady, it was incontestably the cholera.[4] It ravaged first the province of Chang-tong, then turned northwards to Pekin, striking always in its march the most populous towns. At Pekin, its victims were proportionally more numerous than elsewhere. Thence the cholera crossed the Great Wall, and the Chinese say, that it faded away in the land of grass."[5] Fogs do not appear to have been noticed in India—only a peculiar

[4] As there can be no doubt, that the disease was the epidemic cholera, we have proof, that it appeared in China, three years after it sprung up in Bengal. Its course eastward, therefore, was more rapid than to the west.

[5] *The Chinese Empire*, pp. 286-7.

and unusual cloud. An officer, who witnessed the different attacks of cholera in Brigadier Smith's force at Seroon and other places, informed Mr. Orton, that the epidemic was invariably accompanied by a large black cloud, hanging over the place. This, he added, had been so universally remarked, that it had received the name of "the cholera cloud."[6] Many observers have drawn attention to the same circumstance, now and at former epochs. Caius Britannicus states that, in addition to a noisome smell, which preceded the sweating sickness, a "black cloud" was seen to move from place to place, while the pestilential disorder was observed *to follow* exactly the route of the cloud.[7] In Europe, these fogs have been more frequent, and have been better observed. On the first appearance of cholera at Dantzic, on the 27th of May, 1830, there was a very unusual, dense mist,[8] and it became, accordingly, dark long before sunset. It was commonly reported, said Dr. Hamick, by many persons, who were abroad, that the mist had a peculiar, disagreeable smell and taste, so that those exposed to its influence were forced to wash their mouths with water. A similar mist appeared just before the first appearance of the disease in Rheinfeld, and again in Dantzic on the 8th June following. I have heard, continues the above writer, this fact of the concurrence of mists with the first appearance of cholera stated by several; and Dr. Barchewitz obtained written statements of it by conscien-

[6] *On the Epidemic Cholera.*

[7] Van Swietan, *Comment.*, vol. xvi., p. 21.

[8] Mist is not the proper term to apply to these exhalations, as the gaseous matter is generally dry, and uncombined with aqueous vapour—to any extent at least.

tious and intelligent observers, so important did he deem it. The same phenomenon preceded the first outbreak of cholera in England. On the 11th of August, 1831, a thick mist of a tawny-orange colour passed across England, in a direction from south-east to north-west, or from Dover to Liverpool. On the following day, many persons were attacked, in Rochester, with bowel complaints, attended with severe spasms. Fogs were also observed in 1832, and in the subsequent visitations—in 1849, 1854, and in 1866—but it was not until the last-named year, that public attention was specially drawn to the subject. Mr Glaisher, in a letter to the *Times*, states:—"During the prevalence of the epidemic cholera, in the year 1854, my attention was directed to the general and particular atmospheric conditions which prevailed during the visitation. Among them I noticed a certain blue mist, present night and day, which I connected with the epidemic conditions of the atmosphere, and mentioned in my report upon the meteorology of London in relation to the cholera epidemic, addressed to the then President of the Board of Health, and which was published by him. Last Monday, July 30 (1866), on looking from the grounds of the Royal Observatory, Greenwich, under the trees, towards the boundary walls of the park, I saw the same dense, blue mist, which has continued without intermission to the present time, though somewhat less in density this morning. Ordinary mists pass away, when the wind blows with a pressure of ½lb. on the square foot. Since last Monday, we have had pressures of the wind varying from ¼lb. to 9lb. on the same area blowing continuously for sixty to seventy hours, yet there has been no change in this blue appearance. I have

examined the atmosphere daily for this blueness, particularly during the last twelve months, and have never seen anything like it since the year 1854. In my recent quarterly reports to the Registrar-General up to the last published—viz. June 30—I have stated, that no meteorological choleraic conditions had been present, and none certainly appeared up to July 22. During the following week, I was in the Isle of Wight, and on my return to the observatory, on the 30th of July, I at once saw the same phenomenon that I had remarked in September, 1854. I am therefore unable to say when it first appeared. This blue mist is apparent on all sides; it extends fully to the tops of the trees, though it is not then so easy to distinguish. It is most easily discernible through as much atmosphere as possible, viewed from under a tree, looking under other trees. Thus seen, the boundary walls of Greenwich Park, and all objects near them, are coloured blue; or through gaps in trees, if there are others at a sufficient distance to form a background, when it resembles thin smoke from a wood fire. The intensity of the blue is increased when viewed through a telescope with a low power. It is of great importance to know whether it is general over the country. The only other tint of mist I know, connected with the prevalence of epidemics, is that of a yellow mist, perceptible in like manner when scarlatina is prevalent; in neither case is there any excess of humidity in the air." Other observers noted the same phenomenon, and recorded the fact. It was generally supposed, at the time that the phenomenon was a new one, or had not been observed before; and a correspondent, in one of the daily newspapers, who signed himself 'Y,' added:

"Medical practitioners, who are, for the most part, feebly imbued with the spirit of true philosophy, will be disposed to ridicule this notion (of a connection between fog and cholera) from a feeling of mortification, that it should have escaped the attention of their own profession." Had the writer been acquainted with the first edition of this work, he would have known, that the phenomenon had been recorded many years before, and an attempt made to explain the cause of it. The same phenomenon was observed during the prevalence of the cattle plague in 1865. Mr. Garne, of Bushy Grove Farm, Watford, writing to Mr. Woods, respecting an outbreak of this disease, among some lambs, remarked: "Just previous to their being attacked, we had very heavy fogs during the evening, the pastures being covered with what is commonly called cobweb, and the air being, as it were, full of it. In a few days, the grass fields were covered with a peculiar kind of blight, which collected on the shoes similar to a fine powder of a pale chocolate colour; the clovers were covered with mildew. Soon after this, the lambs showed the symptoms I have described to you." This coincidence has been noted from the earliest periods. Thus, God said to His people, by the prophet Amos: "I have smitten you with blasting and mildew;" and we are told, in the next verse, that a pestilence prevailed with men and horses.

That the gaseous matter diffused in the atmosphere, at these periods, is derived from volcanic *foci* may be inferred from the circumstance that fish have been attacked and died, at epidemic periods, the same as terrestrial animals—the very phenomenon that has been observed during volcanic eruptions. In A.D. 222, a pestilence,

which destroyed 100,000 persons, raged in Scotland: at the same time, a great mortality of fish was noticed, and multitudes were washed ashore on the coasts of Great Britain. The old author, Cedrenus, relates that, during the dreadful pestilence, which brooded over almost the whole earth, in the latter part of the sixth century, a vast quantity of fish died in many places. According to Baronius, "a pestilence, which was truly most fatal to the human species, was no less so to aquatic animals; for the banks of rivers were covered with dead fish, which putrefied and infected the air with an intolerable stench." (Book 10.) "In 1240," says Webster, "mortal diseases prevailed, and authors relate, that the fish on the English coast had a battle, in which eleven whales, and a multitude of other fish, were slain and cast ashore. The cause, to which this phenomenon was ascribed, although ludicrous enough, is important; for it strengthens modern observation, that, when pestilential diseases prevail on the surface of the earth, fish often perish beneath the waters." So, also, when the black death was prevailing, there was, in addition to a murrain amongst the cattle, a pestilence, which carried off immense quantities of fish, whose bodies were found on the sea-shore covered with blotches.

The same phenomenon has been observed during the prevalence of the epidemic cholera—multitudes of dead fish having been found, at this time, in ponds in India, Russia, Prussia, and other countries. The subject of the epidemic constitution on animals, during the prevalence of cholera, was brought before the faculty of Vienna, by order of the Imperial Government. They remark, in their Report, after referring to the fact of all classes of animals

being more or less affected, that, "although the peculiar agency is still problematical, yet it appears to be satisfactorily proved, not to depend exclusively on the condition of the atmosphere, since animals that live in water only—as fish, crabs, leeches, &c.—died in great numbers at the time of the cholera epidemic." At Havre, the citadel of which is surrounded by a deep ditch, that always contains a large quantity of fish, a remarkable circumstance, as we are told by Dr. Licardi, took place in the month of August, 1832, the year of the prevalence of the epidemic cholera in France. "It was remarked by many persons," says this writer, "that the water here suddenly changed its colour and became muddy; while *bubbles of gas* rose to the surface, and caused a considerable ebullition. At the same time the fish, and particularly the eels, which are almost constantly at the bottom, were observed to spring above the surface of the water with a convulsive movement, and then to drop again, languid and heavy, into that fluid which, after having been the source of their life and nourishment, was found to act upon them as a poison; for, in a few hours, the surface of the water was covered with dead fish. The inhabitants of the neighbouring sea were not exempt from the operation of the same cause, the sea-shore being likewise covered with an immense quantity of dead fish."[9] *A few days after* the cholera broke out in the town, and raged with considerable violence. The only piscatory epidemics, that have been recorded since then, are the following. Referring to the scarcity of oysters, one writer remarked:

[9] "*Sur la Coincidence des Epidémies humaines avec celles des poissons.*"

"Graziers and milkmen will remember this eventful year by the *cattle plague*, and farmers by the tantalizing weather of harvest; 'gourmands' and 'gourmets,' however, will speak of it as the year of the 'hegira' of natives, when oyster-knives rusted for want of use, and the months with the 'r' in then came, but not the molluscs of the season. It is the same abroad as at home. The dredging on the French coast is a failure, and in Paris those baskets thatched in with straw, which come up from the north-west ports, are hardly to be seen. Epicures go about, repeating to each other a dismal prophecy, that a dozen truffles will be cheaper this winter than a dozen oysters. That the scarcity arose principally from disease, not from excessive consumption of this favourite 'bivalve,' may be inferred from the fact, that, in Norway, where the consumption of oysters is great, a strange illness, which resulted in the sudden death of several persons, was ascribed to the oysters, which were said to be suffering from a species of oyster plague." (The *Standard*, May 28, 1866). Corroborative evidence is thus afforded of the extrication of deleterious substances from subterranean sources, during the prevalence of epidemic diseases; as we know of no other means by which results like those described could be produced.

That the dense fogs so frequently experienced at epidemic periods, are derived from the same reservoirs as those which supply the ducts of volcanos, we may infer from the fact, that some of these fogs appear to obey the same laws as all other and well-known effects of volcanic action. Thus fogs are frequently confined to very narrow boundaries—not only intersecting a country but even a town; so that while one part has been enveloped in a

dense fog, the remainder has been quite free. Although the boundaries of fogs are thus defined, they are, nevertheless, found to extend over considerable spaces in some particular direction; while, in other instances, different localities have been enveloped in fog at the same moment. Not only are fogs confined, in general, to very narrow boundaries, and to particular lines of the earth's surface, but they are sometimes found to progress along these lines and to precede or accompany some particular pestilence. This was the case with the mist, that accompanied the murrain of the seventeenth century, described by Dr. Winklan, and which extended over the same countries as the disease, and had, like it, a regular rate of travelling, —being about fourteen miles an hour.

It may be replied, however, that these fogs are observed in situations, in which no proof has been obtained of the existence of this action, as, also, at long distances from any active volcano. This objection vanishes, when we find, that the same phenomenon is observed at times, when no doubt can exist as to the source whence the gaseous matter is derived. Webster states, that on the 19th May, 1780, a day of singular darkness occurred in New England, and in the Middle States. The heavens were obscured with a vapour, or cloud, of a yellow colour or faint red. On the same day, that this lurid vapour overspread several hundred miles of country in America, Etna began to discharge lava from a new mouth, distant two or three miles from the old crater. It may also be argued, that these mists are only accidental, not invariable accompaniments of epidemic diseases; and, as such, cannot be the cause of their production. This argument is probably a just one; for the poisonous element may, if con-

tained in the air, be sensible neither to the sight nor the smell, as is certainly the case with the poison termed malaria. In fact, the mists and fogs, which accompany the march of epidemics, are merely proofs, that a great evolution of gaseous matter takes place at such periods from the interior of the globe; while all that we are warranted in concluding, is, that a poisonous element of some kind may be extricated at the same time, and from the same sources. It is, also, to be remembered, that these mists are principally observed in cold and damp climates; in warm regions, phenomena of a different kind are experienced. With the exception before mentioned, and the existence of a peculiar "cloud" in the atmosphere, the only evidence of the presence of vapour in the atmosphere in the East and in Asia, has been a redness of the sun's disk, and a peculiar kind of haze in the upper regions with obscurity of the sun's rays.

Independently of the above, there are other proofs of the presence of a deleterious or foreign matter in the atmosphere at all epidemic periods. In the destructive plague which raged in the year 262, and when 5000 persons died daily in Rome, Eusebius states, that the air was so highly corrupt as to form on objects a mould, or coat, like the turbid dew from dead bodies. Webster also remarks, that the air of New York, in 1779, produced astonishing effects in the generation of mould; and the rapidity in the process of putrefaction was almost incredible—a result very common in malarious districts. Impressions of curious figures on garments have also been observed during pestilential periods, while they have also been visible on the doors of houses, and other articles. This was particularly the case during the

plague of 542 and 600. Similar figures, called *cruciculæ*, or little crosses, appeared in the pestilence of 746, and the writers of that period state, that they were looked upon with superstitious horror. The same impressions, or figures, have been observed after volcanic eruptions—as was the case after that of Vesuvius, in 1660, and referred to by Boyle.

If, therefore, epidemic diseases be produced by the presence of a deleterious matter in the atmosphere, as was before inferred; if extraneous substances, extricated from the bowels of the earth, be commonly present in the atmosphere at epidemic periods; and if there be proof, that gaseous matter, inimical to animal life, is given out from volcanic *foci;* while all the great pestilences with which we are acquainted, up to the present time, or before the advent of the epidemic cholera, have prevailed in well-known volcanic regions, we can hardly fail to infer, that they are directly produced by the operation of a poison generated in subterranean reservoirs; more especially as these diseases obey the same laws as other well-known effects of volcanic action. As regards the epidemic cholera, we have no direct proof at present, that it has progressed along a line known to be, or considered to be, volcanic, with the exception of a small portion of this line. Evidence, however, will be adduced hereafter, which tends to show, that volcanic action is actually in existence over a considerable part of this line—and precisely over that part not considered to be volcanic—concussions and other signs of this action having been observed since the advent of the epidemic cholera. But such evidence is not actually required, in order to prove the truth of the proposition now laid

down. If, indeed, epidemic diseases be produced by the extrication of deleterious substances from subterranean reservoirs, the product of a process similar to that of combustion on the surface, the first effect of that process, we may presume, would be the evolution of gaseous matter into the atmosphere above; and the next, disease in the animal creation. As, also, the evolution of this matter is a silent, and, usually, an invisible operation, we should expect to find, that the prevalence of some general disease would be one of the first signs of this process beneath the surface. This, at least, is the conclusion that I should draw on the subject.

These inferences receive support from the opposite series of facts. When free vents have been formed between the exterior and the interior of the globe, or the subterranean reservoirs beneath the surface; either by the formation of a volcano, or by its increased activity, so as to allow of the ready escape of the gaseous matter beneath, the diseases previously witnessed begin to decline. A remarkable example of this is afforded by the volcanic region of the Mediterranean. As is well known, the volcanos in this part of the world are found in three distinct districts, named the Sicilian, the Neapolitan, and the Grecian; but our knowledge is more perfect respecting the two former than the latter. In the first we have Ætna. This volcano appears to have been in a state of activity from the earliest periods of which we have any record; for an eruption caused the Sicani to desert the country, before the Trojan war. Thucydides also states that, between the colonization of Sicily by the Greeks, and the commencement of the Peloponnesian war, in the year 431 B.C., three eruptions

had occurred: while there were nine others before the commencement of the Christian era. But from this date until 1329, only five occurred. In the Neapolitan district, all the volcanos were in a state of *inactivity* from the remotest periods, and until about three centuries before the Christian era. Terrific convulsions then took place in Ischia, and the neighbouring island of Procida, which were followed by eruptions in the former island; for a colony established by Hiero, King of Syracuse, was driven away by the concussions and igneous exhalations. But there was no eruption of Vesuvius until A.D. 79, when Pompeii and Herculaneum were buried under a shower of ashes or, rather, mud—*lava not being ejected.* In fact, we have no account of the flowing of a stream of lava from this volcano until the year 1036, being the seventh eruption from the above date. There was an eruption in 1049, and another in 1138 or 9; after which a pause ensued of 164 years, when, in 1302, a lava stream flowed out from a new vent in the island of Ischia. The next eruption occurred in 1306, between which and 1631 there was only one other (in 1500), and that a slight one. But during this period, or interval of repose, Ætna was in a state of unusual activity: no less than seventy-two eruptions having been recorded from 1329 until the end of the seventeenth century.[1]

[1] Ætna would appear to have thrown out lava in some of the earliest recorded eruptions, for the Carthaginian army was arrested by a stream of melted matter, during its march against Syracuse. It is probable, however, as was the case subsequently with Vesuvius, and as is generally the fact with all *recent* volcanos, that smoke, gaseous matter, and *scoriæ*, were principally given out at that period. In the eruption of 1669, when a new crater was formed, a stream of lava flowed out, and destroyed Mastaluccia, San Pietro, Campo Rotondo,

There had thus been no violent eruption of Vesuvius for 492 years, when, in December, 1631, seven streams of lava poured out at once from the crater, and overflowed several villages on the flanks, and at the foot of the mountain. In 1666, there was another eruption, from which time to the present there has been a constant succession of eruptions, with rarely an interval of rest exceeding ten years.[2] It has been precisely during this last period, that the plague has ceased to prevail epidemically in Europe; while its boundaries, or the extent of its range, have become more and more circumscribed—being now confined to a very narrow circle. The disease, in fact, disappeared, as it were, by zones, the last visitation in England, in the north of France, and in Switzerland, having been in 1666; and, in the south of France, in 1720. Independently of the reasons already given for this gradual subsidence of disease—the great and increasing facility for the escape of gaseous matter from the reservoirs beneath—another reason may be given for this result. If volcanic action be a chemical process, as has been inferred, giving rise to different products at different times, it is probable, that gaseous matter is not generated, or, at least, to the same extent, at that period when melted matter is thrown out on the surface in large quantities. Hence the subsidence of diseases under these circumstances.[3]

and fourteen smaller villages, or hamlets: and was only arrested by the walls—sixty feet high—of Catania. From that time to the present, lava has been constantly thrown out at each eruption.

[2] During this increased activity of Vesuvius, Ætna has been more tranquil; seventeen eruptions only having been recorded from the end of the seventeenth century until the year 1819, while there were thirty-three of Vesuvius.

[3] In the Report of the Cholera, drawn up by order of the Registrar

This result will be still more apparent and remarkable, if we turn to those districts in which extinct volcanos exist or which have become nearly extinct. Thus, in the region of the Andes, the oldest range of volcanos, next to extinct volcanos, epidemics would appear to be unknown, while endemics are extremely rare.[4] Dr. Bryson states that, with some few exceptions, in which ague and malarious fevers exist, both sides of this volcanic chain are extremely salubrious.[5] Again: epidemic diseases are generally unknown in those places possessing mineral springs, which are invariably found in the neighbourhood of extinct volcanos; or in situations, in which evidence exists of the action of subterranean fire, at some remote

General, the writer, Dr. Farr, thus concludes his notice of my work:—1st, The successive outbreaks of cholera in the districts of England have not, in 1832 or 1849, been preceded, accompanied, or followed, by any earthquake, or visible volcanic phenomena; 2ndly, Cholera is, apparently, not more fatal in the immediate neighbourhood of volcanos than it is elsewhere; and 3rdly, The gases, which escape from volcanos, have been analyzed; but the poisonous element has not been identified, or detected, in places suffering from cholera." Nearly the same arguments have been employed, and similar conclusions drawn, by other writers. As will be evident from what has gone before, these facts, so far from being in opposition to my theory, are actually in accordance with it. These writers have confounded volcanic *effects* with volcanic *action*—to which alone I attribute the origin of epidemic diseases. In fact, volcanos, earthquakes, and epidemics, according to my ideas, are merely common effects of a common cause: and although intimately connected together, have no necessary dependence the one on the other.

[4] According to Humboldt, these volcanos scarcely have an eruption once in a century; and, even then, they only throw out mud and water. The period, therefore, when they will become extinct is, probably, not far distant, geologically speaking.

[5] *Statistical Report of the Health of the Navy* from 1837 to 1843.

period. Endemics, also, are very rare in such situations. Hence, nearly all these places escaped the ravages of the epidemic cholera, although many of them were lying in the direct route of the disease, and although surrounded by it in many instances. This was the case at Baku, and most of the mineral springs in Germany. At Swalbach, the epidemic, although prevailing severely in the suburbs, never reached the central part of the town. It appeared, as one of the resident practitioners said to me, as though the town were surrounded by a high wall, beyond which the disease was unable to penetrate. The same result was observed in Spain. A Spanish friend informed me that, in 1854, while the cholera raged fearfully in Mataro and in Vilasar, not a single case occurred in Argentona, possessing mineral springs, and situated about a mile and a half from the former places. And yet, Argentona was crowded with fugitives from both places at the time. With these facts before us, it would seem to be unnecessary to employ other arguments or to adduce further proof, in support of the proposition now laid down, viz. that epidemic diseases are the direct effect of the operation of a cause to which the term volcanic action has been applied. Dr. Hecker, although a contagionist, also infers, that epidemic diseases are produced by, or owe their origin to, what he terms telluric influence. By this term, he does not mean volcanic action, but an undefined, active principle—the vitality, or organism, of our globe. He remarks: "This disease (the black death) was a consequence of violent commotions in the earth's organism; if any disease of cosmical origin can be so considered." This notion, of an organic life in the system of the universe, which is an ancient one, and de-

rived from the East, seems to be a favourite doctrine with Dr. Hecker, and other German writers. But, as Dr. Babington has justly observed, with reference to this opinion, we are constantly furnished with proofs, that that which affects life is not life itself. To assume, therefore, causes, of whose existence we have no proof, in order to account for effects which, after all, they do not explain, is making no real advance in knowledge; and can scarcely be considered otherwise than an indirect method of confessing our ignorance.[6] If, however, instead of supposing that the earth is endowed with an organism, or vitality, of its own, we infer, that the phenomena, which we have now been considering, are the effects of volcanic action; and that this action does not pervade the whole globe, but is confined to particular lines or districts; we refer to an agent, with whose existence we are acquainted, while we are also able, at the same time, to account for nearly all the phenomena witnessed on these occasions.

If the preceding arguments and inferences be allowed, we shall not only be able to understand the cause—the real, the efficient cause—of epidemic diseases, but we shall also be enabled to explain many of the anomalies that belong to other theories, and more especially to that of contagion. As volcanic action takes place along particular lines of the earth's surface, we can at once understand the cause of the progression, or the importation, as it is termed, of epidemic diseases from one country to another, without reference to human intercourse, or commercial traffic. As, also, the boundaries of these lines are of limited extent, an explanation is afforded of the apparent

[6] *Preface to the Translation of Dr. Hecker's work.*

anomaly, that one part of a town is sometimes attacked to the exclusion of the other, and even one side of a street, the opposite not presenting a single case. In a town in Russia, consisting of only one street, all the first cases of cholera happened to be on one side of the street. Observing this, the authorities had a barrier put up to prevent communication between the infected and uninfected sides. The attacks were confined to the former, and the fact was brought forward as demonstrative proof of the contagious nature of the disease, and of the benefit to be derived from isolation. But the same phenomenon, and the same result were observed subsequently in Ireland, although no barrier was erected, and although the communication between the two sides of the street was uninterrupted. A similar result has been observed in numerous instances. Mr. Chandler stated, that at Rotherhithe, the cholera in 1848, not only attacked one side of a street, leaving the other unscathed, but he also remarked, that the disease passed directly *across* certain streets in *a definite line*, like a cannon shot. The same anomaly has been remarked with the diseases of the brute creation. Francis Clater, in his work on Farriery, speaking of one of the murrains of the last century, adds: "A hedge often separated the dead from the living." "I recollect," also remarks Mr. Youatt, "that, in one of our barracks, the majority of the horses on *one side* of the yard were attacked by epidemic catarrh (1833), while there was not a sick horse on the other side."[7] So, also, in the report of the Cattle Plague of 1865, Messrs. Simmonds and Brown state: "Sometimes, the disease has been seen to extend from farm to farm, always on *one side of the road*, the opposite roadsteads re-

[7] The *Veterinarian*, p. 117, 1833.

maining entirely free from the disease" (p. 306). And, yet, with such facts before their eyes, these writers are out-and-out contagionists.

Not only will the poison productive of these diseases be given out along particular lines of the earth's surface, but the gaseous matter will sometimes be extricated in greater abundance in one situation than in another, according to the nature of the soil, or the means of communication that may exist between the interior and the exterior of the globe. Hence one town may be attacked and another spared, although lying apparently in the direct route of the disease. Thus it was that, in the plague of the sixteenth century, the towns of Verona and Padua were nearly depopulated, while the town of Vicenza, which lies between the two, was spared. The year following, however, this town was, in its turn, the theatre of the epidemic, whilst the other two remained unaffected. Schruber also states, that the most perfect health was often preserved near towns severely scourged; while places, the farthest removed, experienced all the horrors of the plague. Similar results have been frequently observed, during the march of the epidemic cholera from India to the shores of America. The same phenomenon is observed during the occurrence of earthquakes, certain spots being shaken, while the intermediate districts are spared—a common result in volcanic regions. Humboldt states, that the natives of South America call these unshaken spots—"bridges!"

Another circumstance well worthy of consideration, and which is entirely fatal to the doctrine of contagion, is the fact, that epidemic diseases frequently break out in different localities, widely separated from each other,

almost simultaneously. Referring to the outbreak of cholera in India, in 1872, Dr. Cunningham, in his report, remarks: "The fact, that the epidemic, over so large an area, attained its greatest violence at or about the same time in many places, separated from each other by hundreds of miles, is of great interest in an epidemiological point of view." The same result has been remarked, not only in other countries, but on different continents, as Europe and America. The cause of the phenomenon will be at once apparent, by a reference to the theory now advanced; other effects of volcanic action, as the earthquake for instance, being frequently felt, at almost the same moment, along the same line, at separate and distinct points.

We can also understand, on the same hypothesis, why isolation is sometimes beneficial, and sometimes useless. As the poison productive of epidemic diseases would not, we may presume, be equally diffused in the atmosphere, but, like malaria, be more concentrated near the spot where it is extricated; while it would become innocuous, at certain distances, by dilution in the surrounding atmosphere; those placed in quarantine, or isolation, would necessarily escape an attack, if the deleterious matter were not given out, or only in small quantity, within the circumscribed area. On the other hand, if the gaseous matter were extricated in greater abundance at a particular spot, those confined there would suffer more than others. Hence, particular establishments, houses, or persons, are sometimes attacked, while others escape; the same whether there be, or whether there be not quarantine, or isolation.

Again: if diseases be produced by the presence of a

gaseous substance in the atmosphere; and if the specific gravity of the gas be greater than that of atmospheric air—as in the case with malaria—an explanation is at once afforded of the well-known fact, that the night air is so injurious at epidemic periods, the same as in malarious districts. During the heat of the day, and the consequent rarefaction of the atmospheric air, the gaseous substance would be elevated into the higher regions; while it would as naturally fall again to the earth, by its own specific gravity, as soon as the rays of the sun were withdrawn. Medical officers in the navy are well aware that, sleeping on deck, or exposure to the night air in an open boat or on shore, in warm and pestiferous climates, is a prolific source of disease. Dr. Clarke states, that "a Danish ship anchored at Long Island, near the Straits of Sunda, and sent twelve of her people on shore to obtain water, where they only remained two nights. Every one of them was seized with fever, of which none recovered, but the rest of the ship's crew remained exempt."[8] "In 1782, the *Assistance*, man-of-war," says Trotter, "wooded and watered at St. Thomas (in the West Indies), and, with a view to expedition, a tent was erected on shore, in which the people employed on these services lodged during the night. On the middle passage, every man, who had slept on shore, was attacked with (yellow) fever and died, while the rest of the ship's company remained perfectly healthy."[9] A striking example of the injurious effect of exposure to the night air has been afforded by Humboldt, in the following narrative. Two rich inhabitants of the city of Mexico—where yellow

[8] *On the Diseases which prevail in Long Voyages.*
[9] *Medicina Nautica*, vol. i., p. 456.

fever is unknown—arrived in the evening at Vera Cruz—in which city the disease is endemic—in order to take the packet, which was to sail the next day for Europe. Being fearful of catching the fever, if they went into a house, they resolved to remain in their carriage all night—*al fresco*—but this did not save them: they were both attacked, in the morning, with black vomit, and died before the evening. Had they gone into the hotel, like the other passengers, none of whom were attacked, they would no doubt have escaped; more particularly if they had shut their bed-room windows. Such an act, however, in the torrid zone, would not be in accordance with the prevalent ideas in England: but it is not in a healthy climate like this, that men can study, with profit and advantage, the causes productive of disease. As the soldier can only acquire a perfect knowledge of his profession on the field of battle: so, also, a medical man must study diseases, there where they exist in their greatest intensity and to the greatest extent—viz. in pestiferous and intertropical climates—if he wishes to become perfectly acquainted with their origin and ætiology.

It is necessary to offer a few words of explanation, respecting an anomaly before referred to. It has been stated, under Law III., that epidemics are rare in mountainous regions: and that, as a general rule, they assume a milder form. There are, however, exceptions to this rule, as they sometimes prevail there more generally, in which case the disease presents a more severe form than on the plains below. The enigma is not difficult of solution. Generally speaking, the poisonous element is only extricated from alluvial soils,

and tertiary formations; in which case, the poison will have become diluted, by its diffusion in the surrounding air, before reaching the higher elevations. Hence the mildness of the attacks, and their rarity. When, however, the gaseous matter escapes from the surface in elevated or mountainous regions, it can only be through particular channels, or springs, as the solidity of the rocks would necessarily prevent its escape through the superincumbent strata. As these springs are more rare than in alluvial districts—where, also, the gaseous matter evidently escapes from the soil itself, and must, therefore, be more equally diffused in the surrounding atmosphere—the poison, when extricated, would necessarily be more concentrated; and hence the severer form of the disease.

Another anomaly may also be referred to. It has been shown, in the previous part of this work, that sporadic, or single, cases of so-called Asiatic cholera exist nearly every year in England; and the same result is witnessed in other countries, and in other diseases, as small-pox for instance. Notwithstanding, the disease only spreads, or becomes epidemic, in particular years. It will also be found, on inquiry, that isolated cases have generally occurred some weeks or months before the actual, or general, outbreak of pestilence. The celebrated Mr. Boyle states, that in 1665, *three months* before the plague broke out in London, a man sent for a physician, complaining of a swelling in the groin, from which circumstance he predicted the plague that followed. Again: it was assumed, and declared in *official* reports, that the cholera was imported into this country in 1866. But a genuine case of Asiatic cholera was admitted into Guy's

Hospital more than a year previously, in May, 1865; while thirty-two deaths from cholera were registered in London, in the course of the same year. There were even deaths, in England, from the same disease the year previously—1864. It is a pity that men, instead of searching for facts, thus draw on their imagination, and feign hypotheses, while quietly seated in their arm-chair? How, then, are these anomalies to be explained? They do not admit of explanation by a reference to the doctrine of contagion, as no reason can be assigned why a disease, presenting the same type and intensity, at all times, should not be propagated as readily at one time as at another, if it be contagious. If, however, these diseases, be produced by volcanic agency, we have only to infer, that a large quantity of deleterious matter is extricated at one time, and over an extended space, and a small quantity at another, at some isolated spot, and the anomaly ceases.

Another phenomenon, inexplicable by the doctrine of contagion, admits of explanation by a reference to that under consideration. This is the fact, that troops on march, in India, have frequently been attacked with cholera, on encamping for the night on an uninhabited spot, in the interior of this vast continent: and this, too, when the disease was neither prevailing in the surrounding districts, nor had been for a long time previously. On one occasion, two corps encamped for the night on separate ground, but *near* to each other. In the morning, one corps was attacked with cholera, but the other remained entirely exempt. Observing this, the sick corps broke up its encampment, and took up a position alongside the healthy one; after which, not a case occurred,

although the sick and the dying were removed at the same time. This was not a solitary instance, many similar ones having been recorded since. The following is another example of the same kind. Referring to the cholera epidemics in India, in 1864-5, one writer remarks: "The troops in Nagpore have suffered on both occasions, and the *high road*, between the terminus of the railroad and Nagpore, has been literally *a valley of death* for months together. Officers, their families, and native travellers innumerable, have fallen victims in attempting to pass it."[1] As the gaseous matter from volcanic *foci* evidently escapes with greater facility in one situation than in another, we may infer, that it found a more ready exit in these localities than in others. As, also, the principal evidence we have of the presence of this matter in the atmosphere, is its effect on man, it is not until an uninhabited district becomes inhabited, that proof is afforded of the extrication of deleterious substances from beneath the surface. These circumstances enable us to explain, why persons, who have fled from an infected town, have frequently been attacked *en route*, falling, as it were, into Charybdis while trying to avoid Scylla. It is commonly supposed, that the fugitives, in these instances, carried the germs of the disease with them: although precisely the same result is observed with those who come from an uninfected, as from an infected district.

Again: it is only by a reference to the theory under discussion, that the outbreak of disease on board ship, in particular instances, can be explained. Such a result has frequently occurred in mid-ocean, although the ship

[1] *Statistical Report of Deaths in Madras;* for 1864.

had not left an infected port, or the crew and passengers been within the focus of the disease previously. As, however, we find, that deleterious matters, derived from volcanic foci, escape from the springs that rise up beneath the waters of the ocean—as shown by their effect on the inhabitants of the deep—we have only to allow, that these matters are afterwards extricated from the surface of the water, and the cause of the outbreak is readily understood. It having been my object to show on a previous occasion, that malaria is not absorbable by water,[2] if the gaseous matter productive of epidemic diseases possesses the same property, it would, instead of being absorbed by the waters of the deep, rise and become extricated into the surrounding atmosphere. That such is the fact, would appear to be conclusively shown by the following narrative, taken from the *Liverpool Times.* "When the *Ann Bridson,* which arrived in this port (Liverpool) from Valparaiso, last week, after a quick passage of eighty-four days, was off the River Plate, on her homeward voyage, the crew and captain suffered the greatest inconvenience from the state of the atmosphere, which, for two days, was so fœtid and offensive as to make it difficult for them to breathe; and we regret to say, that the effect of their exposure to this unwholesome air, did not cease when the atmosphere became pure, but continued to be felt during the remainder of the voyage—many of the crew having been ill from that time until their arrival in this port, and some of them being still much indisposed. Nothing was seen on board, which could enable the captain or

[2] Vide *Causation and Prevention of Disease.* Properties of Malaria, page 89.

crew to account for this unhealthy, or oppressive, state of the atmosphere; but the probability is, that the fœtid smell arose from a submarine discharge of gas, or vapour—a phenomenon which has frequently accompanied earthquakes and volcanic eruptions." The writer, after observing that pestilential gases were formerly given out from Lake Avernus and the Dead Sea, adds: "We feel little doubt, that the painful sensations, experienced on board the *Ann*, were produced by some sudden discharge of mephitic gas under the waters of the ocean, at the point which this vessel was then traversing."[3] [4]

The following anomalies are still more interesting and important. It will be found on investigation, that the pestilential principle, not only spreads from place to place, but that it is also progressive *in the same place*, being productive of different effects at different times. For instance, the plague was almost invariably ushered in by influenza, or measles, or anginas, and by intermittent, continued, spotted, or other fever, and by inflammations. Sydenham says: "I never knew pleurisies, quinsies, and other inflammatory diseases, more common than they were for some weeks preceding the plague in London in 1665." (*Opera*, vol. i., p. 122.) In May, a malignant fever appeared: it was the immediate precursor of the true form of plague. When this subsided in the autumn, the same fever reappeared. The spotted fever, also, which

[3] The *Times*, March 24, 1843.

[4] For an account of a remarkable outbreak of cholera on board two emigrant ships, at precisely *the same spot* on the ocean, but not at the same time, there having been an interval of some weeks between the sailing of the two vessels, see Epidemiology, p. 222 to 224.

prevailed so extensively in Europe, in the 16th and 17th centuries, was almost invariably the precursor of the plague, in which it generally terminated. Hence the remark of Van Swietan, that "the plague has sometimes lain concealed under the mask of other diseases:" and hence, also, the fact, that the bills of mortality have invariably shown an increase—sometimes for two years—previously to the appearance of the plague. This was the case with the plague of 1625, when the total mortality in London rose from 8500 to 11,300 in 1623, and to 12,000 in 1624. This progressiveness in the pestilential principle is fatal to the doctrine of contagion; not only because the matter of contagion could only produce the same specific effects at all times, and under all circumstances, but also because the so-called contagious disease *par excellence*—the plague—would thus appear to be an effect of the same cause as that productive of the majority of diseases—some of which are universally allowed not to be contagious.[5] This is more particularly true with respect to influenza, which no one would even dream of considering to be contagious. Thus, the influenza of 1510 preceded the third visitation of the sweating sickness in England, and the plague in the north of Europe; during which the son of the King of Denmark was carried off. There were four other general influenzas during this century, each of which was followed

[5] It has been my object to show, in the First Part of this work, that the plague is only a severe form of intermittent fever, inasmuch as the two diseases, in certain localities, are found to merge into each other. If so, the plague cannot owe its origin to contagion, it being universally allowed, that intermittent fever is produced by another and a different cause.

by pestilence. The first appearance of the sweating sickness, on the Continent, was preceded by the influenza of 1551: and that of 1557 was followed by a visitation of the plague in Holland—5000 persons having died in Delft alone. Another influenza accompanied the plague that prevailed in Spain, in 1564; and the last influenza of this century, that of 1580, preceded the outbreak of plague in France, during which 40,000 persons died in Paris. Influenza was also contemporaneous with the measles of 1580, 1675, 1732, 1743, and 1775; the small-pox of 1580, 1675, 1743, and 1803; and the nervous fevers of 1658, 1732, 1738, and 1775. In the nervous fever of 1732, "the symptoms," says Dr. Arbuthnot, "were so high in some as to produce a sort of fatuity, or madness." Horses were attacked at the same time, and generally before men. The influenza of 1762, which commenced in Dublin in May—a month later than in London—was accompanied by a fever which much resembled scarlet fever, excepting that there was no eruption. "In June," says Dr. Rutty, "appeared a bilious putrid fever, sometimes attended with petechia, but the miliary type was more frequent."[6]

Not only is influenza accompanied by fever, inflammation, and affections of the chest, but, also, by those of the alimentary canal. This was the case with the catarrh of 1658, which, says Willis, sent, "as if by some blast of the stars," was accompanied by a bloody flux. Similar results were observed in the years 1733, -43, -62, -75, -82 and 1803. The epidemic cholera, also, as already shown, has been preceded and followed by influenza, both in Asia and in Europe. In fact, there is hardly a disease,

[6] *A Chronological History of the Weather and the Seasons.*

that does not, at one time or another, either commence with or terminate in influenza. As Dr. Thompson, in his Annals of Influenza, has remarked: "The affinity of influenza to other diseases, especially to those of an epidemic character, is illustrated by numerous facts recorded in these Annals: such epidemics being nearly contemporaneous, and sometimes superseding, or being superseded by, catarrhal fever." If, however, we infer, that influenza is only one of a numerous class of diseases —all those termed epidemic—derived from the same root, and springing up from the same cause: and if we also allow, that this disease is not, and cannot be, produced or propagated by contagion, it follows, that all the other diseases, belonging to the same class, must also be produced by a different cause. These conclusions granted, there is an end of the contagious origin of diseases.

There is another circumstance of some importance as regards the elucidation of the present subject. This is, that the cause productive of influenza is the same now as at former epochs, for the symptoms are identical. As one writer, M. Delafond, has remarked, while referring to influenza: "Nothing can more forcibly prove the definite character of the influence, which produces the disease, than the similarity of the symptoms, during several centuries, and under such different degrees of civilization. We find the affection, in our comparatively luxurious days, manifesting the same phenomena as it exhibited, when the presence chamber of sovereigns was strewed with straw: the entrance of aristocratic mansions obstructed with decaying vegetable matter; and a lantern required at night to guide the wary steps of the citizen through the 'slabby streets' of the metropolis." The

same remarks will apply to the majority of specific diseases—as smallpox, scarlet fever, plague, and the different forms of fever. The poison productive of them, therefore, as, also, its chemical properties and composition, must be the same now as at former epochs: and the process that gives rise to it, must be as regular and as uniform as that productive of prussic acid.[7] But a contagious matter would necessarily have become changed, during so many centuries, and after passing through the bodies of so many men. As it has not, we have another proof of the non-contagious origin of diseases.

Another circumstance is, that when the reigning epidemic appears in one locality, other and different diseases spring up in other places, situated on the same *pestilential line*. Thus, the great plague in Constantinople was contemporary with the fatal angina and dysentery in America, in 1751 and -55. In 1758 and -59, the measles in America were contemporary with, or, rather preceded, the extensive Levantine plague of 1760. Plague prevailed again in the East in 1781, and was accompanied by epidemics in America. And Webster adds: "One remark I will hazard on the strength of facts within the present century (the eighteenth), that whenever malignant diseases prevail extensively in Europe and America, the plague rages in Egypt and Constantinople."

[7] These inferences are strengthened by another circumstance. The same remedy, according to my investigations and conclusions, is a specific, or antidote, in the epidemic cholera, and for the whole class of endemics. If for endemics, it will also be a specific for epidemics, both classes being evidently the product of one and the self-same poison. See *The Antidotal Treatment of Disease.*

(*Loc. cit.*, vol. 1, p. 346.) Sometimes, the pestilential principle, in one country, seems to expend itself chiefly on the brute creation; while, in the same year or succession of years, its principal operation, in a neighbouring country, is experienced by mankind. Thus, in 1712 and 13, the cattle in Italy, Germany, and other countries were suffering from a desolating murrain, while in Austria, Hungary and the East, the plague raged among men. So, again, in 1770, while the plague was raging in Turkey and Poland, a mortal distemper swept away the cattle in Holland, Flanders, and England. In America, malignant fevers prevailed at the same time. We have here proof, independently of other arguments and conclusions, that all specific diseases, both in the human and the brute creation, owe their origin to the self-same cause; thus verifying the axiom of Sir Isaac Newton—"a multiplicity of effects, but a paucity of causes." Results like these would be perfect anomalies viewed by the doctrine of contagion, or by any other and previous theory: but they are readily explained by that under consideration, inasmuch as we witness similar phenomena in the physical world; or, a variation in the effects at different points of the volcanic line, at the same moment or nearly so.

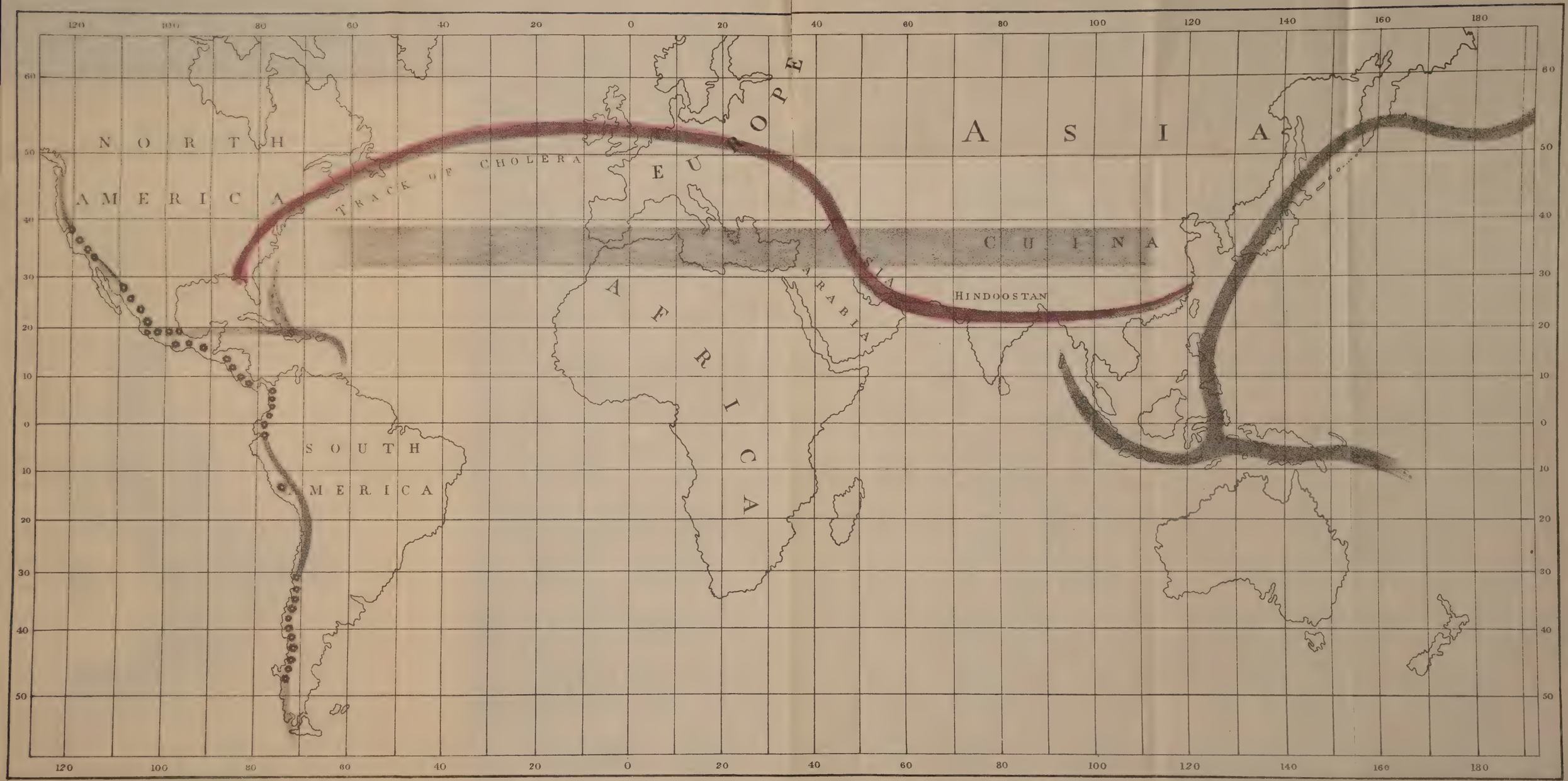
Although it is unnecessary to refer to all the anomalies that belong to other theories, there is one, that well deserves consideration before closing these remarks. This is, that when some particular and previously unknown pestilence has sprung up, it is invariably accompanied or followed by other new diseases; while the intensity of those previously existing is increased. Thus, the plague, which first appeared in Europe in the fifth century, was followed by small-pox—a new disease—and, subsequently,

by angina, erysipelas, leprosy, and the sweating sickness. The epidemic cholera, also, has been followed by diphtheria, typhoid fever, and rinderpest; and by an increase in the frequency and malignancy of all other diseases. Referring to the year 1837, Dr. Law remarked: "If ever there was a time, when atmospheric influence forced itself upon our notice as an active agent, in producing and in modifying disease, it has been within the last few years. Within this period not only have we been visited (in Ireland) by diseases to which we had hitherto been strangers, but every known and familiar disease has exhibited itself under an aspect of malignity *quite new* to it. Thus, in addition to cholera and influenza, erysipelas, malignant scarlatina, and diffuse inflammation of the cellular membrane, prevailed to an unprecedented extent. The cases of small-pox now also crowded upon us, and it was now that fever began to prevail."[8] Although we might allow, supposing that diseases owe their origin to contagion, that one particular affection should spring up, and continue to prevail for a series of years afterwards; it will be somewhat difficult to understand, how a number of accidental circumstances should occur, productive of so many different effects at almost the same moment. Granting that the spread of pestilential diseases is due to contagion, they must have arisen, in the first instance, from some accidental circumstance—local or individual. As M. Trousseau remarks: "Spontaneous origin is then an incontrovertible fact, in the development of even the most contagious diseases. In fact, as contagion necessarily implies the presence of two persons—the one giving, the other

[8] On Fever, in *Dublin Medical Journal.*

receiving, the morbific germ—it is only a trite (*banale*) truth to say, that, with the first who was attacked with a contagious disease, the malady arose spontaneously: that it was entirely produced under the influence of causes, which are completely unknown to us."[9] Still more difficult it will be to understand, why the spread of a disease like the plague or the cholera should cause an increase in all ordinary diseases, even in that of intermittent fever, which is universally allowed not to be contagious; and which is known to be produced by a very different cause. Intermittent fever not only prevailed epidemically, during the whole period of the prevalence of the plague, but it has also been the accompaniment of the epidemic cholera in nearly all countries excepting England, where it has been replaced by typhoid fever. "Nothing," remark the writers of the Madras Report on the Epidemic Cholera, "is more common than to observe the raging of this disease together, and at the same time, with intermittent fever." In Spain, intermittents were so common, on the subsidence of the epidemic cholera, in 1834, that hardly a person was exempt in the Provinces of Valencia, Murcia, and Andalusia. If, however, all these diseases be produced by one and the same cause, it is not surprising, that they should prevail simultaneously, and in the same intensity.

[9] *Clinique Médicale*, tom. i. Art. Contagion.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